ORALLY ADMINISTERED SMALL PEPTIDES SYNERGIZE STATIN ACTIVITY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of 10/423,830, filed on April 25, 2003, which is a continuation-in-part of 10/273,386, filed on October 16, 2002, which is a continuation-in-part of 10/187,215, filed on June 28, 2002, which is a continuation-in-part of 09/896,841, filed on June 29, 2001, which is a continuation-in-part of USSN 09/645,454, filed on August 24, 2000 all of which are incorporated herein by reference in their entirety for all purposes. This application also claims benefit of and priority to USSN 60/494,449, filed on August 11, 2003, which is also incorporated herein by reference in its entirety for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

[0002] This work was supported by United States Public Health Service and National Heart, Lung, and Blood Institute Grants HL30568 and HL34343. The Government of the United States of America may have certain rights in this invention.

FIELD OF THE INVENTION

[0003] This invention relates to the field of atherosclerosis. In particular, this invention pertains to the identification of a class of peptides that are orally administrable and that ameliorate one or more symptoms of atherosclerosis.

BACKGROUND OF THE INVENTION

[0004] Cardiovascular disease is a leading cause of morbidity and mortality, particularly in the United States and in Western European countries. Several causative factors are implicated in the development of cardiovascular disease including hereditary predisposition to the disease, gender, lifestyle factors such as smoking and diet, age, hypertension, and hyperlipidemia, including hypercholesterolemia. Several of these factors, particularly hyperlipidemia and hypercholesteremia (high blood cholesterol concentrations) provide a significant risk factor associated with atherosclerosis.

[0005] Cholesterol is present in the blood as free and esterified cholesterol within lipoprotein particles, commonly known as chylomicrons, very low density lipoproteins (VLDLs), low density lipoproteins (LDLs), and high density lipoproteins (HDLs). Concentration of total cholesterol in the blood is influenced by (1) absorption of cholesterol from the digestive tract, (2) synthesis of cholesterol from dietary constituents such as carbohydrates, proteins, fats and ethanol, and (3) removal of cholesterol from blood by tissues, especially the liver, and subsequent conversion of the cholesterol to bile acids, steroid hormones, and biliary cholesterol.

[0006] Maintenance of blood cholesterol concentrations is influenced by both genetic and environmental factors. Genetic factors include concentration of rate-limiting enzymes in cholesterol biosynthesis, concentration of receptors for low density lipoproteins in the liver, concentration of rate-limiting enzymes for conversion of cholesterols bile acids, rates of synthesis and secretion of lipoproteins and gender of person. Environmental factors influencing the hemostasis of blood cholesterol concentration in humans include dietary composition, incidence of smoking, physical activity, and use of a variety of pharmaceutical agents. Dietary variables include amount and type of fat (saturated and polyunsaturated fatty acids), amount of cholesterol, amount and type of fiber, and perhaps amounts of vitamins such as vitamin C and D and minerals such as calcium.

[0007] Epidemiological studies show an inverse correlation of high density lipoprotein (HDL) and apolipoprotein (apo) A-I levels with the occurrence of atherosclerotic events (Wilson *et al.* (1988) *Arteriosclerosis* 8: 737-741). Injection of HDL into rabbits fed an atherogenic diet has been shown to inhibit atherosclerotic lesion formation (Badimon *et al.* (1990) *J. Clin. Invest.* 85: 1234-1241).

[0008] Human apo A-I has been a subject of intense study because of its anti-atherogenic properties. Exchangeable apolipoproteins, including apo A-I, possess lipid-associating domains (Brouillette and Anantharamaiah (1995) *Biochim. Biophys. Acta* 1256:103-129; Segrest *et al.* (1974) *FEBS Lett.* 38: :247-253). Apo A-I has been postulated to possess eight tandem repeating 22mer sequences, most of which have the potential to form class A amphipathic helical structures (Segrest *et al.* (1974) *FEBS Lett.* 38: :247-253). Characteristics of the class A amphipathic helix include the presence of

positively charged residues at the polar-nonpolar interface and negatively charged residues at the center of the polar face (Segrest *et al.* (1974) FEBS Lett. 38: 247-253; Segrest *et al.* (1990) *Proteins: Structure, Function, and Genetics* 8: 103-117). Apo A-I has been shown to strongly associate with phospholipids to form complexes and to promote cholesterol efflux from cholesterol-enriched cells. The delivery and maintenance of serum levels of apo A-I to effectively mitigate one or more symptoms of atherosclerosis has heretofore proven elusive.

SUMMARY OF THE INVENTION

[0009] This invention provides novel peptides administration of which mitigates one or more symptoms of atherosclerosis and other inflammatory conditions such as rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, osteoporosis, Alzheimer's disease, congestive heart failure, endothelial dysfunction, viral illnesses such as influenza A, and diseases such as multiple sclerosis. In particular, it was a discovery of this invention that peptides comprising a class A amphipathic helix when formulated with "D" amino acid residue(s) and/or having protected amino and carboxyl termini can be orally administered to an organism, are readily taken up and delivered to the serum, and are effective to mitigate one or more symptoms of atherosclerosis. In certain embodiments, the peptides can be formulated with all "L" amino acid residues and are still effective, particular when administered by routes other than oral administration.

[0010] It was also a discovery that "small" peptides (*e.g.* ranging in length from three amino acides to about 11 amino acids) having hydrophobic terminal amino acids or terminal amino acids rendered hydrophobic by one or more hydrophobic blocking goups and having internal acidic and/or basic, and/or aliphatic, and/or aromatic amino acids as described herin are also capable of mitigating one or more symptoms of atherosclerosis or other pathologies characterized by an inflammatory response.

[0011] The peptides of this invention are typically effective to stimulate the formation and cycling of pre-beta high density lipoprotein-like particles and/or to promote lipid transport and detoxification.

[0012] The peptides described herein are also effective for preventing the onset or inhibiting or eliminating one or more symptoms of osteoporosis.

[0013] It was also a surprising discovery that the peptides can be used to enhance (*e.g.* synergically enhance) the activity of statins and/or Ezetimibe or other cholesterol uptake inhibitors, thereby permitting the effective use of statins or cholesterol uptake inhibitors at lower dosages and/or cause the statins or cholesterol uptake inhibitors to be significantly more anti-inflammatory at any given dose.

[0014] In certain embodiments, this invention provides peptides or a combination of peptides that ameliorates one or more symptoms of an inflammatory condition (*e.g.* atherosclerosis atherosclerosis, rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, osteoporosis, Altzheimer's disease, a viral illnesses, *etc.*). Certain preferred peptides are characterized by the formula: X^1-X^2-X^3_n-X^4 where n is 0 or 1; X^1 is a hydrophobic amino acid and/or bears a hydrophobic protecting group; X^4 is a hydrophobic amino acid and/or bears a hydrophobic protecting group; and, when n is 0, X^2 is an amino acid selected from the group consisting of an acidic amino acid, a basic amino acid, and a histidine; and, when when n is 1: X^2 and X^3 are independently an acidic amino acid, a basic amino acid, an aliphatic amino acid, or an aromatic amino acid such that when X^2 is an acidic amino acid; X^3 is a basic amino acid, an aliphatic amino acid, or an aromatic amino acid; when X^2 is a basic amino acid; X^3 is an acidic amino acid, an aliphatic amino acid, or an aromatic amino acid; and when X^2 is an aliphatic or aromatic amino acid, X^3 is an acidic amino acid, or a basic amino acid. Certain preferred peptides convert pro-inflammatory HDL to anti-inflammatory HDL or make anti-inflammatory HDL more anti-inflammatory. In certain embodiments, the peptide does not have the amino acid sequence Lys-Arg-Asp-Ser (SEQ ID NO:238) in which Lys, Arg, Asp, and Ser are all L amino acids. Peptides of this invention include peptides according to the formula above, and/or peptides comprising a peptide of the formula above and/or concatamers of such peptides.

[0015] In certain embodiments, X^1 and X^4 are independently selected from the group consisting of alanine (Ala), valine (Val), leucine (Leu), isoleucine (Ile), proline (Pro), phenylalanine (Phe), tryptophan (Trp), methionine (Met), serine (Ser) bearing a hydrophobic protecting group, beta-naphthyl alanine, alpha-naphthyl alanine, norleucine, cyclohexylalanine, threonine (Thr) bearing a hydrophobic protecting group, tyrosine (Tyr) bearing a hydrophobic protecting group, lysine (Lys) bearing a hydrophobic protecting group, arginine (Arg) bearing a hydrophobic protecting group, ornithine (Orn) bearing a hydrophobic protecting group, aspartic acid (Asp) bearing a hydrophobic protecting group,

cysteine (Cys) bearing a hydrophobic protecting group, and glutamic acid (Glu) bearing a hydrophobic protecting group.

[0016] In certain embodiments, the peptide is a tri-mer (*i.e.*, n is 0). In certain tri-mers, X^1 is Glu, Leu, Lys, Orn, Phe, Trp, or norLeu; X^2 is acidic (*e.g.* aspartic acid, glutamic acid, *etc.*), or basic (*e.g.* lysine, arginine, histidine, *etc.*) and X^4 is Ser, Thr, Ile, Leu, Trp, Tyr, Phe, or norleu. In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 3. In certain embodiments, the peptide is a protected trimer as shown in Table 3.

[0017] In certain embodiments, n is 1 and the peptide is or comprises a tetramer in which X^2 and X^3 are independently an acidic amino acid or a basic amino acid such that when X^2 is an acidic amino acid, X^3 is a basic amino acid and when X^2 is a basic amino acid, X^3 is an acidic amino acid. X^1 and X^4 can include independently selected amino acids, *e.g.*, as indicated above. In certain embodiments, X^2 and X^3 are independently selected from Asp, Glu, Lys, Arg, and His. In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 4. In certain embodiments, the peptide is a protected tetramer as show in Table 4.

[0018] In still another embodiment, n is 1 and the peptide is or comprises a tetramer in which X^2 and X^3 are independently an acidic, a basic, or a aliphatic amino acid with one of X^2 or X^3 being an acidic or a basic amino acid such that when X^2 is an acidic or a basic amino acid, X^3 is an aliphatic amino acid; and when X^3 is an acid or a basic amino acid, X^2 is an aliphatic amino acid. X^1 and X^4 can include independently selected amino acids, *e.g.*, as indicated above. In certain embodiments, X^2 and X^3 are independently selected from the group consisting of Asp, Glu, Lys, Arg, His, and Ile, more preferably from the group consisting of Asp, Arg, Leu, and Glu. In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 5. In certain embodiments, the peptide is a protected tetramer as show in Table 5.

[0019] In another embodiment, n is 1 and the peptide is or comprises a tetramer in which X^2, X^3 are independently an acidic, a basic, or an aromatic amino acid with one of X^2 or X^3 being an acidic or a basic amino acid such that when X^2 is an acidic or a basic amino acid, X^3 is an aromatic amino acid; and when X^3 is an acid or a basic amino acid, X^2 is an aromatic amino acid. X^1 and X^4 can include independently selected amino acids,

e.g., as indicated above. In certain embodiments, X^2 and X^3 are independently selected from the group consisting of Asp, Arg, Glu, Trp, Tyr, Phe, and Lys. In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 6. In certain embodiments, the peptide is a protected tetramer as show in Table 6.

[0020] This invention also provides for peptides that are or comprise a pentamer (5-mer) characterized by the formula: X^1-X^2-X^3-X^4-X^5, where X^1 is a hydrophobic amino acid and/or bears a hydrophobic protecting group; X^5 is a hydrophobic amino acid and/or bears a hydrophobic protecting group; and X^2, X^3, and X^4 are independently selected aromatic amino acids or histidine; and the peptide converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory. In certain embodiments, X^1 and X^5 are independently selected from the group consisting of alanine (Ala), valine (Val), leucine (Leu), isoleucine (Ile), proline (Pro), phenylalanine (Phe), tryptophan (Trp), methionine (Met), phenylalanine (Phe), tryptophan (Trp), methionine (Met), serine (Ser) bearing a hydrophobic protecting group, beta-naphthyl alanine, alpha-naphthyl alanine, norleucine, cyclohexylalanine, threonine (Thr) bearing a hydrophobic protecting group, tyrosine (Tyr) bearing a hydrophobic protecting group, lysine (Lys) bearing a hydrophobic protecting group, arginine (Arg) bearing a hydrophobic protecting group, ornithine (Orn) bearing a hydrophobic protecting group, aspartic acid (Asp) bearing a hydrophobic protecting group, cysteine (Cys) bearing a hydrophobic protecting group, and glutamic acid (Glu) bearing a hydrophobic protecting group. In certain embodiments X^2, X^3, and X^4 are independently is selected from the group consisting of Phe, Val, Trp, Tyr, and His. In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 7. In certain embodiments, the peptide is a protected tetramer as show in Table 7.

[0021] This invention also provides for larger peptides that ameliorate one or more symptoms of an inflammatory condition. In certain embodiments, the peptide ranges in length from 5 to 11 amino acids; the terminal amino acids are hydrophobic amino acids and/or bear hydrophobic protecting groups; the non-terminal amino acids form at least one acidic domain and at least one basic domain; and the peptide converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory.

[0022] In certain embodiments, the peptide ranges in length from 5 to 11 amino acids; the terminal amino acids are hydrophobic amino acids and/or bear hydrophobic protecting groups; the non-terminal amino acids form at least one acidic domain or one basic domain and at least one aliphatic domain; and the peptide converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory.

[0023] In other embodiments, the peptide ranges in length from 5 to 11 amino acids; the terminal amino acids are hydrophobic amino acids and/or bear hydrophobic protecting groups; the non-terminal amino acids form at least one acidic domain or one basic domain and at least one aromatic domain; and the peptide converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory.

[0024] In still other embodiments, the peptide ranges in length from 6 to 11 amino acids; the terminal amino acids are hydrophobic amino acids and/or bear hydrophobic protecting groups; the non-terminal amino acids form at least one aromatic domain or two or more aromatic domains separated by one or more histidines; and the peptide converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory.

[0025] This invention also provides for peptides that ameliorate one or more symptoms of an inflammatory condition and that comprise one or more amphipathic helices. Thus, this invention includes a peptide or a concatamer of a peptide that ranges in length from about 10 to about 30 amino acids; that comprises at least one class A amphipathic helix; that comprises one or more aliphatic or aromatic amino acids at the center of the non-polar face of said amphipathic helix; that protects a phospholipid against oxidation by an oxidizing agent; and that is not the D-18A peptide. . In certain embodiments, the peptide comprises the amino acid sequence of a peptide listed in Table 2 or Table 10. In certain embodiments, the peptide is a protected tetramer as show in Table 2 or Table 10.

[0026] In certain embodiments, the peptides of this invention protect a phospholipid (*e.g.*, 1-palmitoyl-2-arachidonoyl-sn-glycero-3-phosphorylcholine (PAPC), 1-stearoyl-2-arachidonoyl-sn-glycero-3-phosphorylcholine (SAPC)), 1-stearoyl-2-

arachidonyl-sn-glycero-3-phosphorylethanolamine (SAPE)) against oxidation by an oxidizing agent (*e.g.* 13(S)-HPODE, 15(S)-HPETE, HPODE, HPETE, HODE, HETE, *etc.*).

[0027] Any of the peptides described herein can bear one or more hydrophobic protecting groups on the amino terminal amino acid (*e.g.*, X^1) and/or the carboxyl terminal amino acid (*e.g.* X^4, X^5, *etc.*). The protecting group(s) can be attached to the amino or carboxyl terminus and/or to a side chain (R group) of the amino acid. The protecting group(s) can be directly coupled (*e.g.* through a covalent bond) or indirectly coupled (*e.g.* through a linker). Preferred hydrophobic protecting groups include, but are not limited to t-butoxycarbonyl (Boc), Fmoc, nicotinyl, OtBu, a benzoyl group, an acetyl (Ac), a carbobenzoxy, methyl, ethyl, a propyl, a butyl, a pentyl a hexyl ester, an N-methyl anthranilyl, and a 3 to 20 carbon alkyl, amide, a 3 to 20 carbon alkyl group, 9-fluoreneacetyl group, 1-fluorenecarboxylic group, 9-fluorenecarboxylic group, 9-fluorenone-1-carboxylic group, benzyloxycarbonyl (is also called carbobenzoxy mentioned above), Xanthyl (Xan), Trityl (Trt), 4-methyltrityl (Mtt), 4-methoxytrityl (Mmt), 4-methoxy-2,3,6-trimethyl-benzenesulphonyl (Mtr), Mesitylene-2-sulphonyl (Mts), 4,4-dimethoxybenzhydryl (Mbh), Tosyl (Tos), 2,2,5,7,8-pentamethyl chroman-6-sulphonyl (Pmc), 4-methylbenzyl (MeBzl), 4-methoxybenzyl (MeOBzl), Benzyloxy (BzlO), Benzyl (Bzl), Benzoyl (Bz), 3-nitro-2-pyridinesulphenyl (Npys), 1-(4,4-dimethyl-2,6-dioxocyclohexylidene)ethyl (Dde), 2,6-dichlorobenzyl (2,6-DiCl-Bzl), 2-chlorobenzyloxycarbonyl (2-Cl-Z), 2-bromobenzyloxycarbonyl (2-Br-Z), benzyloxymethyl (Bom), cyclohexyloxy (cHxO),t-butoxymethyl (Bum), t-butoxy (tBuO), t-Butyl (tBu), trifluoroacetyl (TFA), 4[N-{1-(4,4-dimethyl-2,6-dioxocyclohexylidene)-3-methyldibutyl)-amino}benzyl ester (ODmab), α-allyl ester (OAll), 2-phenylisopropyl ester (2-PhiPr), 1-[4,4-dimethyl-2,6-dioxycyclohex-1-yl-idene)ethyl (Dde), and the like. In certain embodiments, the said hydrophobic protecting group is selected from the group consisting of Boc, Fmoc, nicotinyl, and OtBu. In certain embodiments, the N-terminus of the peptide is blocked with a protecting group selected from the group consisting of Boc-, Fmoc-, and Nicotinyl- and/or the C-terminus of the peptide is blocked with a protecting group selected from the group consisting of tBu, and OtBu.

[0028] The peptides can also, optionally, include at least one D amino acid. In certain embodiments, the peptides include a plurality of D- amino acids or can even

compirse all D-amino acids. In certain embodiments, the peptide comprise alternating D- and L- amino aicds. The peptides can also be all L-form amino acids. The peptides can be isolated (*e.g.* substanitaly pure), dry or in solution, and/or combined with a pharmacologically acceptable excipient. In certain embodiments, the peptide is mixed with a pharmacologically acceptable excipient suitable for oral administration to a mammal (*e.g.* a human or a non-human mammal). The peptide can be provided as a unit formulation in a pharmaceutically acceptable excipient and/or as a time release formulation.

[0029] The peptides can also be coupled to one or more biotins (*e.g.* directly, through a linker, and/or through the amino acid side chain). In certain embodiments, the biotin is coupled to a lysine (Lys).

[0030] This invention also provides a pharmaceutical formulation comprising one or more of the peptides described herein and a pharmaceutically acceptable excipient. Typically the peptide(s) are present in an effective dose. The peptide(s) can also be provided as a time release formulation and/or as a unit dosage formulation. In certain embodiments, the formulation is formulated for oral administration. In certain embodiments, the formulation is formulated for administration by a route selected from the group consisting of oral administration, nasal administration, rectal administration, intraperitoneal injection, intravascular injection, subcutaneous injection, transcutaneous administration, inhalation administration, and intramuscular injection.

[0031] Also provided is a kit comprising a container containing one or more of the peptides described herein and instructional materials teaching the use of the peptide(s) in the treatment of a pathology characterized by inflammation (*e.g.* atherosclerosis atherosclerosis, rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, osteoporosis, Altzheimer's disease, a viral illnesses, *etc.*).

[0032] This invention also provides a method of mitigating (*e.g.* reducing or eliminating) one or more symptoms of atherosclerosis in a mammal (human or non-human mammal). The method typically involves administering to the mammal an effective amount of one or more of the peptides described herein. The peptide can be administered in a in a pharmaceutically acceptable excipient (*e.g.* for oral administration) and can, optionally be administered in conjunction (*e.g.* before, after, or simultaneously) with a

lipid. The administering can comprise administering said peptide by a route selected from the group consisting of oral administration, nasal administration, rectal administration, intraperitoneal injection, intravascular injection, subcutaneous injection, transcutaneous administration, and intramuscular injection. In certain embodiments, the mammal is a mammal diagnosed as having one or more symptoms of atherosclerosis. In certain embodiments, the mammal is a mammal diagnosed as at risk for stroke or atherosclerosis.

[0033] In another embodiment, this invention provides method of mitigating one or more symptoms of an inflammatory pathology (*e.g.*, atherosclerosis, rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, osteoporosis, Altzheimer's disease and a viral illnesses). The method typically involves administering to the mammal an effective amount of one or more of the peptides described herein. The peptide can be administered in a in a pharmaceutically acceptable excipient (*e.g.* for oral administration) and can, optionally be administered in conjunction (*e.g.* before, after, or simultaneously) with a lipid. The administering can comprise administering said peptide by a route selected from the group consisting of oral administration, nasal administration, rectal administration, intraperitoneal injection, intravascular injection, subcutaneous injection, transcutaneous administration, and intramuscular injection. In certain embodiments, the mammal is a mammal diagnosed as having one or more symptoms of of the inflammatory pathology. In certain embodiments, the mammal is a mammal diagnosed as at risk for the inflammatory pathology.

[0034] The peptides of this invention also act synergistically with statins and/or with a selective cholesterol uptake inhibitor (*e.g.* Ezetimibe). The method typically involves coadministering with the statin and/or cholesterol uptake inhibitor an effective amount of one or more of the peptides described herein. In certain embodiments, the statin is selected from the group consisting of cerivastatin, atorvastatin, simvastatin, pravastatin, fluvastatin, lovastatin. rosuvastatin, and pitavastatin. The peptide can be administered before, after, or simultaneously with the statin and/or the cholesterol uptake inhibitor. The peptide and/or said statin and/or cholesterol uptake inhibitor can be administered as a unit dosage formulation. In certain embodiments, the administering comprises administering said peptide and/or said statin by a route selected from the group consisting of oral administration, nasal administration, rectal administration, intraperitoneal injection, intravascular injection, subcutaneous injection, transcutaneous

administration, and intramuscular injection. The mammal includes, but is not limited to a mammal diagnosed as having one or more symptoms of atherosclerosis or diagnosed as at risk for stroke or atherosclerosis.

[0035] This invention also provides a method of mitigating one or more symptoms associated with atherosclerosis in a mammal. The method typically involves administering a statin and/or a selective cholesterol uptake inhibitor; and an effective amount of one or more peptides described herein, where the the effective amount of the statin and/or cholesterol uptake inhibitor is lower than the effective amount of a statin or a cholesterol uptake inhibitor administered without the peptide(s). In certain embodiments, the effective amount of the peptide(s) is lower than the effective amount of the peptide administered without the statin and/or cholesterol uptake inhibitor. In certain embodiments, the statin is selected from the group consisting of cerivastatin, atorvastatin, simvastatin, pravastatin, fluvastatin, lovastatin. rosuvastatin, and pitavastatin. The peptide can be administered before, after, or simultaneously with the statin and/or the cholesterol uptake inhibitor. The peptide and/or said statin and/or cholesterol uptake inhibitor can be administered as a unit dosage formulation. In certain embodiments, the administering comprises administering said peptide and/or said statin by a route selected from the group consisting of oral administration, nasal administration, rectal administration, intraperitoneal injection, intravascular injection, subcutaneous injection, transcutaneous administration, and intramuscular injection. The mammal includes, but is not limited to a mammal diagnosed as having one or more symptoms of atherosclerosis or diagnosed as at risk for stroke or atherosclerosis. The mammal includes, but is not limited to a mammal diagnosed as having one or more symptoms of atherosclerosis or diagnosed as at risk for stroke or atherosclerosis.

[0036] In still another embodiment, this invention provides a method of reducing or inhibiting one or more symptoms of osteoporosis in a mammal. The method typically involves administering to the mammal one or more peptide(s) described herein, where peptide is administered in a concentration sufficient to reduce or eliminate one or more symptoms of osteoporosis. In certain embodiments, the peptide(s) are administered in a concentration sufficient to reduce or eliminate decalcification of a bone. In certain embodiments, the peptide(s) are administered in a concentration sufficient to induce

recalcification of a bone. The peptide(s) can be combined with a pharmacologically acceptable excipient (*e.g.*, an excipient suitable for oral administration to a mammal).

[0037] In certain embodiments, the methods and/or peptides of this invention exclude any one or more peptides disclosed in WO 97/36927, and/or U.S. Patent 6,037,323, and/or U.S. Patent 4,643,988 and/or in Garber *et al.* (1992) *Arteriosclerosis and Thrombosis,* 12: 886-894. In certain embodiments this invention excludes any one or more peptides disclosed in U.S. Patent 4,643,988 and/or in Garber et al (1992) that were synthesized with all enantiomeric amino acids being L amino acids or synthesized with D amino acids where the peptides are blocking groups. In certain embodiments, this invention excludes peptides having the formula A_1-B_1-B_2-C_1-D-B_3-B_4-A_2-C_2-B_5-B_6-A_3-C_3-B_7-C_4-A_4-B_8-B_9 (SEQ ID NO:(SEQ ID NO:1) wherein A_1, A_2, A_3 and A_4 are independently aspartic acid or glutamic acid, or homologues or analogues thereof; B_1, B_2, B_3, B_4, B_5, B_6, B_7, B_8 and B_9 are independently tryptophan, phenylalanine, alanine, leucine, tyrosine, isoleucine, valine or α-naphthylalanine, or homologues or analogues thereof; C_1, C_2, C_3 and C_4 are independently lysine or arginine, and D is serine, threonine, alanine, glycine, histidine, or homologues or analogues thereof; provided that, when A_1 and A_2 are aspartic acid, A_3 and A_4 are glutamic acid, B_2 and B_9 are leucine, B_3 and B_7 are phenylalanine, B_4 is tyrosine, B_5 is valine, B_6, B_8, and D are alanine, and C_1, C_2, C_3 and C_4 are lysine, B_1 is not tryptophan.

[0038] In certain embodiments, this invention excludes any one or more peptides in WO 97/36927 and/or D variants thereof. Particular embodiments exclude one or more of the following: apoprotein A, apoprotein A-1, apoprotein A-2, apoprotein A4, apoprotein B, apoprotein B-48, apoprotein B-100, apoprotein C, apoprotein C-1, apoprotein C-2, apoprotein C-3, apoprotein D, apoprotein E as described in WO 97/36927.

[0039] In certain embodiments, Also excluded are any one or more peptides disclosed in U.S. Patent 6,037,323 and/or D variants thereof. Particular embodiments exclude apo A-I agonist compounds comprising (i) an 18 to 22-residue peptide or peptide analogue that forms an amphipathic .alpha.-helix in the presence of lipids and that comprises the formula: Z_1 -X_1-X_2-X_3-X_4-X_5-X_6-X_7-X_8-X_9-X_{10}-X_{11}-X_{12}-X_{13} -X_{14}-X_{15}-X_{16}-X_{17}-X_{18}-Z_2, (SEQ ID NO:2), where X_1 is Pro (P), Ala (A), Gly (G), Asn (N), Gln (Q) or D-Pro (p); X_2 is an aliphatic amino acid; X_3 is Leu (L); X_4 is an acidic amino acid; X_5 is

Leu (L) or Phe (F); X_6 is Leu (L) or Phe (F); X_7 is a basic amino acid; X_8 is an acidic amino acid; X_9 is Leu (L) or Trp (W); X_{10} is Leu (L) or Trp (W); X_{11} is an acidic amino acid or Asn (N); X_{12} is an acidic amino acid; X_{13} is Leu (L), Trp (W) or Phe (F); X_{14} is a basic amino acid or Leu (L); X_{15} is Gln (Q) or Asn (N); X_{16} is a basic amino acid; X_{17} is Leu (L); X_{18} is a basic amino acid; Z_1 is H_2 N-- or RC(O)NH--; Z_2 is --C(O)NRR, --C(O)OR or --C(O)OH or a salt thereof; each R is independently --H, (C_1-C_6) alkyl, (C_1-C_6) alkenyl, (C_1-C_6) alkynyl, (C_5-C_{20}) aryl, (C_6 -C_{26}) alkaryl, 5-20 membered heteroaryl or 6-26 membered alkheteroaryl or a 1 to 4-residue peptide or peptide analogue in which one or more bonds between residues 1-7 are independently a substituted amide, an isostere of an amide or an amide mimetic; and each "-" between residues X_1 through X_{18} independently designates an amide linkage, a substituted amide linkage, an isostere of an amide or an amide mimetic; or (ii) an altered form of formula (I) in which at least one of residues X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{16}, X_{17} or X_{18} is conservatively substituted with another residue, and/or D variants thereof.

[0040] In certain embodiments, this invention excludes peptides having the sequence Lys-Arg-Asp-Ser (SEQ ID NO:238) and in certain embodiments, this invention excludes peptides having the sequence Lys-Arg-Asp-Ser (SEQ ID NO:238) in which Lys-Arg-Asp and Ser are all L amino acids.

Definitions.

[0041] The terms "polypeptide", "peptide" and "protein" are used interchangeably herein to refer to a polymer of amino acid residues. The terms apply to amino acid polymers in which one or more amino acid residues is an artificial chemical analogue of a corresponding naturally occurring amino acid, as well as to naturally occurring amino acid polymers.

[0042] The term " class A amphipathic helix" refers to a protein structure that forms an α-helix producing a segregation of a polar and nonpolar faces with the positively charged residues residing at the polar-nonpolar interface and the negatively charged residues residing at the center of the polar face (*see, e.g.,* " Segrest *et al.* (1990) *Proteins: Structure, Function, and Genetics* 8: 103-117).

[0043] The term "ameliorating" when used with respect to "ameliorating one or more symptoms of atherosclerosis" refers to a reduction, prevention, or elimination of one or more symptoms characteristic of atherosclerosis and/or associated pathologies. Such a reduction includes, but is not limited to a reduction or elimination of oxidized phospholipids, a reduction in atherosclerotic plaque formation and rupture, a reduction in clinical events such as heart attack, angina, or stroke, a decrease in hypertension, a decrease in inflammatory protein biosynthesis, reduction in plasma cholesterol, and the like. "Ameliorating one or more symptoms of atherosclerosis" can also refer to improving blood flow to vascular beds affected by atherosclerosis.

[0044] The term "enantiomeric amino acids" refers to amino acids that can exist in at least two forms that are nonsuperimposable mirror images of each other. Most amino acids (except glycine) are enantiomeric and exist in a so-called L-form (L amino acid) or D-form (D amino acid). Most naturally occurring amino acids are "L" amino acids. The terms "D amino acid" and "L amino acid" are used to refer to absolute configuration of the amino acid, rather than a particular direction of rotation of plane-polarized light. The usage herein is consistent with standard usage by those of skill in the art.

[0045] The term "protecting group" refers to a chemical group that, when attached to a functional group in an amino acid (*e.g.* a side chain, an alpha amino group, an alpha carboxyl group, *etc.*) blocks or masks the properties of that functional group. Preferred amino-terminal protecting groups include, but are not limited to acetyl, or amino groups. Other amino-terminal protecting groups include, but are not limited to alkyl chains as in fatty acids, propionyl, formyl and others. Preferred carboxyl terminal protecting groups include, but are not limited to groups that form amides or esters. The term "side chain protection groups" refers to protecting groups that protect/block a side-chain (*i.e.* an R group) of an amino acid. Side-chain protecting groups include, but are not limited to amino protecting groups, carboxyl protecting groups and hydroxyl protecting groups such as aryl ethers and guanidine protecting groups such as nitro, tosyl *etc.*

[0046] The phrase "protect a phospholipid from oxidation by an oxidizing agent" refers to the ability of a compound to reduce the rate of oxidation of a phospholipid (or the amount of oxidized phospholipid produced) when that phospholipid is contacted with an

oxidizing agent (*e.g.* hydrogen peroxide, 13-(S)-HPODE, 15-(S)-HPETE, HPODE, HPETE, HODE, HETE, *etc.*).

[0047] The terms "low density lipoprotein" or "LDL" is defined in accordance with common usage of those of skill in the art. Generally, LDL refers to the lipid-protein complex which when isolated by ultracentrifugation is found in the density range d = 1.019 to d = 1.063.

[0048] The terms "high density lipoprotein" or "HDL" is defined in accordance with common usage of those of skill in the art. Generally "HDL" refers to a lipid-protein complex which when isolated by ultracentrifugation is found in the density range of d = 1.063 to d = 1.21.

[0049] The term "Group I HDL" refers to a high density lipoprotein or components thereof (*e.g.* apo A-I, paraoxonase, platelet activating factor acetylhydrolase, *etc.*) that reduce oxidized lipids (*e.g.* in low density lipoproteins) or that protect oxidized lipids from oxidation by oxidizing agents.

[0050] The term "Group II HDL" refers to an HDL that offers reduced activity or no activity in protecting lipids from oxidation or in repairing (*e.g.* reducing) oxidized lipids.

[0051] The term "HDL component" refers to a component (*e.g.* molecules) that comprises a high density lipoprotein (HDL). Assays for HDL that protect lipids from oxidation or that repair (*e.g.* reduce oxidized lipids) also include assays for components of HDL (*e.g.* apo A-I, paraoxonase, platelet activating factor acetylhydrolase, *etc.*) that display such activity.

[0052] The term "human apo A-I peptide" refers to a full-length human apo A-I peptide or to a fragment or domain thereof comprising a class A amphipathic helix.

[0053] A "monocytic reaction" as used herein refers to monocyte activity characteristic of the "inflammatory response" associated with atherosclerotic plaque formation. The monocytic reaction is characterized by monocyte adhesion to cells of the vascular wall (*e.g.* cells of the vascular endothelium), and/or chemotaxis into the subendothelial space, and/or differentiation of monocytes into macrophages.

[0054] The term "absence of change" when referring to the amount of oxidized phospholipid refers to the lack of a detectable change, more preferably the lack of a statistically significant change (*e.g.* at least at the 85%, preferably at least at the 90%, more preferably at least at the 95%, and most preferably at least at the 98% or 99% confidence level). The absence of a detectable change can also refer to assays in which oxidized phospholipid level changes, but not as much as in the absence of the protein(s) described herein or with reference to other positive or negative controls.

[0055] The following abbreviations are used herein: PAPC: L-α-1-palmitoyl-2-arachidonoyl-*sn*-glycero-3-phosphocholine; POVPC: 1-palmitoyl-2-(5-oxovaleryl)-*sn*-glycero-3-phosphocholine; PGPC: 1-palmitoyl-2-glutaryl-*sn*-glycero-3-phosphocholine; PEIPC: 1-palmitoyl-2-(5,6-epoxyisoprostane E_2)-*sn*-glycero-3-phsophocholine; ChC18:2: cholesteryl linoleate; ChC18:2-OOH: cholesteryl linoleate hydroperoxide; DMPC: 1,2-ditetradecanoyl-rac-glycerol-3-phosphocholine; PON: paraoxonase; HPF: Standardized high power field; PON: paraoxonase; BL/6: C57BL/6J; C3H:C3H/HeJ.

[0056] The term "conservative substitution" is used in reference to proteins or peptides to reflect amino acid substitutions that do not substantially alter the activity (specificity (*e.g.* for lipoproteins))or binding affinity (*e.g.* for lipids or lipoproteins)) of the molecule. Typically conservative amino acid substitutions involve substitution one amino acid for another amino acid with similar chemical properties (*e.g.* charge or hydrophobicity). The following six groups each contain amino acids that are typical conservative substitutions for one another: 1) Alanine (A), Serine (S), Threonine (T); 2) Aspartic acid (D), Glutamic acid (E); 3) Asparagine (N), Glutamine (Q); 4) Arginine (R), Lysine (K); 5) Isoleucine (I), Leucine (L), Methionine (M), Valine (V); and 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W).

[0057] The terms "identical" or percent "identity," in the context of two or more nucleic acids or polypeptide sequences, refer to two or more sequences or subsequences that are the same or have a specified percentage of amino acid residues or nucleotides that are the same, when compared and aligned for maximum correspondence, as measured using one of the following sequence comparison algorithms or by visual inspection. With respect to the peptides of this invention sequence identity is determined over the full length of the peptide.

[0058] For sequence comparison, typically one sequence acts as a reference sequence, to which test sequences are compared. When using a sequence comparison algorithm, test and reference sequences are input into a computer, subsequence coordinates are designated, if necessary, and sequence algorithm program parameters are designated. The sequence comparison algorithm then calculates the percent sequence identity for the test sequence(s) relative to the reference sequence, based on the designated program parameters.

[0059] Optimal alignment of sequences for comparison can be conducted, *e.g.*, by the local homology algorithm of Smith & Waterman, *Adv. Appl. Math.* 2:482 (1981), by the homology alignment algorithm of Needleman & Wunsch, *J. Mol. Biol.* 48:443 (1970), by the search for similarity method of Pearson & Lipman (1988) *Proc. Natl. Acad. Sci. USA* 85:2444, by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Dr., Madison, WI), or by visual inspection (*see generally* Ausubel *et al., supra*).

[0060] One example of a useful algorithm is PILEUP. PILEUP creates a multiple sequence alignment from a group of related sequences using progressive, pairwise alignments to show relationship and percent sequence identity. It also plots a tree or dendogram showing the clustering relationships used to create the alignment. PILEUP uses a simplification of the progressive alignment method of Feng & Doolittle (1987) *J. Mol. Evol.* 35:351-360. The method used is similar to the method described by Higgins & Sharp (1989) *CABIOS* 5: 151-153. The program can align up to 300 sequences, each of a maximum length of 5,000 nucleotides or amino acids. The multiple alignment procedure begins with the pairwise alignment of the two most similar sequences, producing a cluster of two aligned sequences. This cluster is then aligned to the next most related sequence or cluster of aligned sequences. Two clusters of sequences are aligned by a simple extension of the pairwise alignment of two individual sequences. The final alignment is achieved by a series of progressive, pairwise alignments. The program is run by designating specific sequences and their amino acid or nucleotide coordinates for regions of sequence comparison and by designating the program parameters. For example, a reference sequence can be compared to other test sequences to determine the percent sequence

identity relationship using the following parameters: default gap weight (3.00), default gap length weight (0.10), and weighted end gaps.

[0061] Another example of algorithm that is suitable for determining percent sequence identity and sequence similarity is the BLAST algorithm, which is described in Altschul *et al.* (1990) *J. Mol. Biol.* 215: 403-410. Software for performing BLAST analyses is publicly available through the National Center for Biotechnology Information (http://www.ncbi.nlm.nih.gov/). This algorithm involves first identifying high scoring sequence pairs (HSPs) by identifying short words of length W in the query sequence, which either match or satisfy some positive-valued threshold score T when aligned with a word of the same length in a database sequence. T is referred to as the neighborhood word score threshold (Altschul *et al*, *supra*). These initial neighborhood word hits act as seeds for initiating searches to find longer HSPs containing them. The word hits are then extended in both directions along each sequence for as far as the cumulative alignment score can be increased. Cumulative scores are calculated using, for nucleotide sequences, the parameters M (reward score for a pair of matching residues; always > 0) and N (penalty score for mismatching residues; always < 0). For amino acid sequences, a scoring matrix is used to calculate the cumulative score. Extension of the word hits in each direction are halted when: the cumulative alignment score falls off by the quantity X from its maximum achieved value; the cumulative score goes to zero or below, due to the accumulation of one or more negative-scoring residue alignments; or the end of either sequence is reached. The BLAST algorithm parameters W, T, and X determine the sensitivity and speed of the alignment. The BLASTN program (for nucleotide sequences) uses as defaults a wordlength (W) of 11, an expectation (E) of 10, M=5, N=-4, and a comparison of both strands. For amino acid sequences, the BLASTP program uses as defaults a wordlength (W) of 3, an expectation (E) of 10, and the BLOSUM62 scoring matrix (*see* Henikoff & Henikoff (1989) *Proc. Natl. Acad. Sci. USA* 89:10915).

[0062] In addition to calculating percent sequence identity, the BLAST algorithm also performs a statistical analysis of the similarity between two sequences (*see, e.g.*, Karlin & Altschul (1993) *Proc. Natl. Acad. Sci. USA* ,90: 5873-5787). One measure of similarity provided by the BLAST algorithm is the smallest sum probability (P(N)), which provides an indication of the probability by which a match between two nucleotide or amino acid sequences would occur by chance. For example, a nucleic acid is considered

similar to a reference sequence if the smallest sum probability in a comparison of the test nucleic acid to the reference nucleic acid is less than about 0.1, more preferably less than about 0.01, and most preferably less than about 0.001.

[0063] The term "D-18A peptide" refers to a peptide having the sequence: D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F (SEQ ID NO:3) where all of the enantiomeric amino acids are D form amino acids.

[0064] The term "coadministering" or "concurrent administration", when used, for example with respect to a peptide of this invention and another active agent (*e.g.* a statin), refers to administration of the peptide and the active agent such that both can simultaneously achieve a physiological effect. The two agents, however, need not be administered together. In certain embodiments, administration of one agent can precede administration of the other, however, such coadministering typically results in both agents being simultaneously present in the body (*e.g.* in the plasma) at a significant fraction (*e.g.* 20% or greater, preferably 30% or 40% or greater, more preferably 50% or 60% or greater, most preferably 70% or 80% or 90% or greater) of their maximum serum concentration for any given dose.

[0065] The term "detoxify" when used with respect to lipids, LDL, or HDL refers the removal of some or all oxidizing lipids and/or oxidized lipids. Thus, for example, the uptake of all or some HPODE and/or HPETE (both hydroperoxides on fatty acids) will prevent or reduce entrance of these peroxides into LDLs and thus prevent or reduce LDL oxidation.

[0066] The term "pre-beta high density lipoprotein-like particles" typically refers to cholesterol containing particles that also contain apoA-I and which are smaller and relatively lipid-poor compared to the lipid: protein ratio in the majority of HDL particles. When plasma is separated by FPLC, these "pre-beta high density lipoprotein-like particles" are found in the FPLC fractions containing particles smaller than those in the main HDL peak and are located to the right of HDL in an FPLC chromatogram as shown in related application USSN 10/423,830.

[0067] The phrase "reverse lipid transport and detoxification" refers to the removal of lipids including cholesterol, other sterols including oxidized sterols, phospholipids, oxidizing agents, and oxidized phospholipids from tissues such as arteries and transport

out of these peripheral tissues to organs where they can be detoxified and excreted such as excretion by the liver into bile and excretion by the kidneys into urine. Detoxification also refers to preventing the formation and/or destroying oxidized phospholipids as explained herein.

[0068] The term "biological sample" as used herein refers to any sample obtained from a living organism or from an organism that has died. Examples of biological samples include body fluids, tissue specimens, cells and cell lines taken from an organism (*e.g.* a human or non-human mammal).

[0069] The term "amide" when referring to a hydrophobic protecting group or a hydrophobic blocking group includes a simple amide to methylamide or ethylamide. The term also includes alkyl amides such as CO-NH-R where R is methyl, ethyl, *etc.* (*e.g.* up to 7, preferably 9, more preferably 11 or 13 carbons).

[0070] The term "D-peptide" refers to a peptide in which one or more of the enantiiomeric amino acids comprising the peptide are D form amino acids. In certain embodiments, a plurality of the enantiomeric amino acids are D form amino acids. In certain embodiments, at least half of the enantiomeric amino acids are D form amino acids. In certain embodiments, the peptide comprises alternating D- and L-form amino acids. In certain embodiments, all of the enantiomeric amino acids are D form amino acids.

[0071] The term "L-peptide" refers to a peptide in which all of the amino acids (enantiomeric amino acids) are L-form amino acids.

BRIEF DESCRIPTION OF THE DRAWINGS

[0072] Figure 1 illustrates a synthesis scheme for the solution phase synthesis of peptides according to this invention.

[0073] Figure 2 illustrates the process for synthesizing a tetrapeptide using the process outlined in Figure 1.

[0074] Figure 3 shows that pre-incubation (pre-treatment) but not co-incubation (Co-inc) of Boc-Lys(Boc)-Arg-Asp-Ser(tBu)-OtBu (synthesized from all D-amino acids) (SEQ ID NO:238 in Table 4) inhibited LDL-induced monocyte chemotactic activity

produced by human artery wall cells (HAEC). The cells were either pre-incubated with 125 μg/ml, 250 μg/ml, or 500 μg/ml of the peptide, the peptide was then removed and LDL at 100 μg/ml cholesterol with fresh medium was added or the same concentrations of peptide were added together with the LDL and monocyte chemotactic activity determined.

[0075] Figure 4 shows that the addition of the tetrapeptide described in Figure 3 to the drinking water of apoE null mice converted HDL and the post-HDL FPLC fractions from pro-inflammatory to anti-inflammatory similar to D-4F. The tetrapeptide or D-4F were added to the drinking water of the mice (n= 4 for each condition) at a concentration of 5 μg/ml for 18 hours. The mice were bled and their lipoproteins were separated by FPLC. A control human LDL at 100 μg/ml of Cholesterol was added (LDL) or not added (No Addition) to human artery wall cocultures or was added together with HDL at 50 μg/ml from a normal human control subject (+Control HDL) or HDL at 50 μg/ml from apoE null mice that received drinking water without peptide (+Water Control HDL) or received the tetrapeptide (+D-Tetra HDL) or D-4F (+D4F HDL) or the post-HDL FPLC fractions from apoE null mice that did not receive the peptide (+Water Control post HDL) or from mice that did receive the tetrapeptide (+D-Tetra post HDL) or received D-4F (+D4F post HDL)were added at 20 μg/ml together with the control human LDL at 100 μg/ml of Cholesterol. After 8 hours the supernatants were assayed for monocyte chemotactic activity.

[0076] Figure 5 shows that apoE null mice receiving D-tetrapeptide or D-4F in their drinking water have LDL that induces less monocyte chemotactic activity. The LDL from the FPLC fractions of the mice described in Figure 4 was added to the cocultures at 100 μg/ml. After 8 hours the supernatants were assayed for monocyte chemotactic activity.

[0077] Figure 6 shows that SEQ ID NO:258 from Table 4 (designated D-11 in the figure) when synthesized from all D-amino acids or D-4F given orally renders HDL anti-inflammatory in apoE null mice but a peptide containing the same D-amino acids as in D-4F but arranged in a scrambled sequence that prevents lipid binding did not. Five hundred micrograms of SEQ ID NO: 258 synthesized from D-amino acids (D-11) or 500 μg of D-4F (D-4F) or 500 μg of scrambled D-4F (Scramb. Pept.) were instilled via a tube into the stomachs of female, 3 month old apoE null mice, (n=4) and the mice were bled 20min (20

min after gavage) or 6 hours later (6 hr after gavage). Plasma was separated and HDL was isolated by FPLC. Cultures of human aortic endothelial cells received medium alone (No Addition/Assay Controls), standard normal human LDL at 100 μgm/mL cholesterol without (LDL/Assay Controls) or together with standard control human HDL (LDL+Control HDL/Assay Controls) at 50 μgm/mL cholesterol, or control human LDL at 100 μgm/mL cholesterol was added with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received the scrambled D-4F peptide (LDL+ Scramb.Pept. HDL), or D-4F (LDL+ D-4F HDL) or SEQ ID NO: 258 made from all D-amino acids (LDL+D-11 HDL). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields. * indicates p<0.001.

[0078] Figure 7 shows that apoE null mice receiving D-4F or SEQ ID NO:258 from Table 4 synthesized from D-amino acids (designated D-11) (but not from mice that received scrambled D-4F) have LDL that induces less monocyte chemotactic activity. The LDL from the FPLC fractions of the mice described in Figure 6 was added to the cultures at 100 μg/ml. After 8 hours the supernatants were assayed for monocyte chemotactic activity.* indicates p<0.001, **indicates p<0.01.

[0079] Figure 8 shows that HDL was converted from pro-inflammatory to anti-inflammatory after addition of SEQ ID NO:238 in Table 4 synthesized from D amino aicids (designated D-1) to the chow of apoE null mice (200 μg/gm chow for 18 hours). Assay Controls: No Addition, no addition to the cocultures; LDL ,a standard control human LDL was added to the cocultures; + Control HDL, a control normal human HDL was added to the cocultures. Chow LDL, LDL from mice that received chow alone; +Chow Autolog. HDL, HDL from the mice that received Chow alone was added together with the LDL from these mice; + D-1 Autolog. HDL, HDL from the mice receiving the peptide was added together with the LDL from these mice to the cocultures and monocyte chemotactic activity was determined.

[0080] Figure 9 shows that the tetrapeptide (SEQ ID NO:258 in Table 4) was ten times more potent than SEQ ID NO:238 in vitro. The tetrapeptide was added or not added in a pre-incubation to human artery wall cell cocultures at 100, 50, 25 or 12.5 μgm/mL and incubated for 2 hrs. The cultures were then washed. Some wells then received

medium alone (No Addition). The other wells either received standard normal human LDL at 100 μgm/mL cholesterol (LDL) or received this LDL together with a standard control human HDL (LDL+ Control HDL) at 50 μgm/mL cholesterol and were incubated for 8 hrs. Culture supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields. The wells that received the tetrapeptide in the 2 hr pre-incubation at the concentrations noted above followed by the addition of LDL at 100 μgm/mL cholesterol are indicated in the figure (LDL+tetrapeptide, in μgm/ml).

[0081] Figure 10 shows that SEQ ID NOs:243, 242, and 256 from Table 4 (designated Seq No.5, Seq No.6, and Seq No. 9, respectively in the figure) convert pro-inflammatory HDL from apoE null mice to anti-inflammatory HDL. Two month old female apo E null mice (n=4 per treatment) fasted for 18 hrs, were injected intraperitoneally with L-tetrapeptides at 20 μgm peptide/mouse or were injected with the saline vehicle (Saline Vehicle). Two hours later, blood was collected from the retroorbital sinus under mild anesthesia with Isofluorine. Plasma was separated and HDL was isolated by FPLC. HDL inflammatory / anti-inflammatory properties were then determined. Cultures of human aortic endothelial cells received medium alone (No Addition), standard normal human LDL at 100 μgm/mL cholesterol without (LDL) or together with standard control human HDL (LDL+Control HDL) at 50 μgm/mL cholesterol, or standard control human LDL at 100 μgm/mL cholesterol with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received the tetrapeptides or the saline vehicle (LDL+HDL from mice injected intraperitoneally). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields.

[0082] Figure 11 shows that SEQ ID NO:258 from Table 4 (designated S-11 in the Figure) converts pro-inflammatory HDL from apoE null mice to anti-inflammatory HDL better than SEQ ID NO:254 and SEQ ID NO:282 (designated S-7 and S-35, respectively in the Figure). Two-month-old female apo E null mice (n=4 per treatment) fasted for 18 hrs, were injected intraperitoneally with S-7 or S-11 or S-35, at 20 μgm peptide/mouse or were injected with the saline vehicle (Saline Vehicle). Two hours later, blood was collected from the retroorbital sinus under mild anesthesia with Isofluorine. Plasma was

separated and LDL and HDL were isolated by FPLC. HDL inflammatory / anti-inflammatory properties were then determined. Cultures of human aortic endothelial cells received medium alone (No Addition/Assay Controls), standard normal human LDL at 100 μgm/mL cholesterol without (LDL/Assay Controls) or together with standard control human HDL (+Control HDL/Assay Controls) at 50 μgm/mL cholesterol, or mouse LDL at 100 μgm/mL cholesterol with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received S-7, or S-11 or S-35 (LDL + S-7 HDL. LDL+ S-11 HDL, LDL+S-35 HDL, respectively) or the saline vehicle (LDL+Saline HDL)). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields.*p<0.001.

[0083] Figure 12. The LDL from the FPLC fractions of the mice described in Figure 11 was added to the cells at 100 μg/ml. After 8 hours the supernatants were assayed for monocyte chemotactic activity. Assay Controls are as described in Figure 11. Saline LDL, LDL from mice injected with the saline vehicle; S-7 LDL, LDL from mice injected with SEQ ID NO:254 from Table 4 as described in Figure 11; S-11 LDL, LDL from mice injected with SEQ ID NO:258 from Table 4 as described in Figure 11;S-35, LDL from mice injected with SEQ ID NO:282 as described in Figure 9. # p<0.001.

[0084] Figure 13 shows serum Amyloid A (SAA) plasma levels after injection of peptides. SAA levels in plasma were measured 24 hours after injection of the peptides described in Figures 11 and 12. * $p < 0.001$.

[0085] Figure 14 shows that SEQ ID NO:258 from Table 4 when synthesized from all L-amino acids and given orally converts pro-inflammatory HDL from apoE null mice to anti-inflammatory HDL. Female, 3 month old apoE null mice, (n=4), were given 200 micrograms in water of the peptide described as SEQ ID NO:258 from Table 4, which was synthesized from all L-amino acids (designated S-11 in the figure). The peptide or water without peptide was administered by stomach tube and the mice were bled 4 hours later. A second group of four mice were given access to standard mouse chow in powdered form and containing 200 micrograms of the S-11, which was synthesized from all L-amino acids and added per1.0 gram of powdered mouse chow in a total of 4 grams of powdered mouse chow containing a total of 800 micrograms of the peptide for the cage of four mice or they were given the same powdered mouse chow without peptide. The chow was

available to the mice overnight and by morning the chow was consumed and the mice were bled. Plasma was separated and HDL was isolated by FPLC. HDL inflammatory / anti-inflammatory properties were then determined. Cultures of human aortic endothelial cells received medium alone (No Addition/Assay Controls), standard normal human LDL at 100 μgm/mL cholesterol without (LDL/Assay Controls) or together with standard control human HDL (LDL+Cont.HDL/Assay Controls) at 50 μgm/mL cholesterol, or control human LDL at 100 μgm/mL cholesterol with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received no peptide (LDL+ No Peptide HDL) or L-S-11 (LDL+L-S-11 HDL) by stomach tube (By gastric gavage) or in the mouse chow (Powdered diet). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields. $p<0.001$.

[0086] Figure 15 L-S-11, when synthesized from all L-amino acids and given orally increased plasma paraoxonase activity. The plasma from the mice described in Figure 14 was assayed for paraoxonase activity (PON Activity, which is shown in the figure as Units per 500 μl of plasma). No peptide, mice that received water or food alone without peptide. L-S-11, mice given 200 micrograms in water or food of the peptide described as SEQ ID NO:256 from Table 4 as described in Figure 14. $P<0.001$.

[0087] Figure 16. SEQ ID NO:238 (designated D-1) and SEQ ID NO:258 (designated D-11) from Table 4 when synthesized from all D-amino acids and given orally renders HDL anti-inflammatory in apoE null mice but SEQ ID NO:238, when synthesized from all L-amino acids (L-1) and given orally did not. Female, 3 month old apoE null mice, (n=4), were given access to standard mouse chow in powdered form and containing 0.5 milligram of each peptide added per1.0 gram of powdered mouse chow in a total of 4 grams of powdered mouse chow containing a total of 2.0 milligrams of the peptide for the cage of four mice or they were given the same powdered mouse chow without peptide. The chow was available to the mice for 24 hrs at which time the chow was consumed and the mice were bled. Plasma was separated and HDL was isolated by FPLC. Cultures of human aortic endothelial cells received medium alone (No Addition/Assay Controls), standard normal human LDL at 100 μgm/mL cholesterol without (LDL/Assay Controls) or together with standard control human HDL (LDL+Control HDL/Assay Controls) at 50

μgm/mL cholesterol, or control human LDL at 100 μgm/mL cholesterol was added with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received no peptide (LDL+ No Pep. HDL), or SEQ ID NO:238 made from all L-amino acids (LDL+L-1 HDL),or SEQ ID NO:238 made from all D-amino acids (LDL+D-1 HDL) or SEQ ID NO:258 made from all D-amino acids (LDL+D-11 HDL). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields. * indicates $p<0.01$ and ** indicates $p<0.001$.

[0088] Figure 17. SEQ ID NO:238 (D-1) and SEQ ID NO:258 (D-11) from Table 4 when synthesized from all D-amino acids and given orally renders HDL anti-inflammatory and reduces LDL-induced monocyte chemotactic activity in apoE null mice but SEQ ID NO:238, when synthesized from all L-amino acids and given orally, did not. Plasma from the mice described in Figure 16 was separated and HDL and LDL were isolated by FPLC. Cultures of human aortic endothelial cells received medium alone (No Addition/Assay Controls), standard normal human LDL at 100 μgm/mL cholesterol without (LDL/Assay Controls) or together with standard control human HDL (LDL+Control HDL/Assay Controls) at 50 μgm/mL cholesterol, or autologous mouse LDL at 100 μgm/mL cholesterol alone (mLDL) or with mouse HDL at 50 μgm/mL cholesterol obtained from mice that received no peptide (mLDL+ No Pep. HDL),or SEQ ID NO:238 made from all L-amino acids (mLDL+L-1 HDL), or SEQ ID NO:238 made from all D-amino acids (mLDL+D-1 HDL) or SEQ ID NO:258 made from all D-amino acids (mLDL+D-11 HDL). The cultures were incubated for 8 hrs. The supernatants were then assayed for monocyte chemotactic activity. The values are mean +/- SD of the number of migrated monocytes in 9 high power fields. * indicates $p<0.05$, ** indicates $p<0.01$ and *** indicates $p<0.001$.

[0089] Figure 18. SEQ ID NO:258 from Table 4 synthesized from all D-amino acids (D-11), when given orally to mice, raised HDL cholesterol concentrations while giving SEQ ID NO:238 synthesized from either L- or D-amino acids (L-1or D-1, respectively) orally did not. Plasma HDL-cholesterol concentrations from the mice that are described in Figures 16 and 17 were determined. No Peptide HDL, plasma HDL-cholesterol in mice that received no peptide; L-1 HDL, plasma HDL-cholesterol in mice

that received SEQ ID NO:238 synthesized from L-amino acids; D-1 HDL, plasma HDL-cholesterol in mice that received SEQ ID NO:238 synthesized from D-amino acids; D-11 HDL, plasma HDL-cholesterol in mice that received SEQ ID NO:258 synthesized from D-amino acids. *indicates p<0.001.

[0090] Figure 19. SEQ ID NO:258 from Table 4 synthesized from all D-amino acids (D-11) when given orally to mice raised HDL paraoxonase (PON) activity while giving SEQ ID NO:238 synthesized from either L- or D- amino acids (L-1, D-1, respectively) orally did not. Paraoxonase activity in the HDL described in Figure 18 was determined. The values are activity per 500 microliters of plasma. *indicates p<0.001.

[0091] Figure 20. Pravastatin and D-4F act synergistically to reduce aortic lesions as determine in en face preparations in apoE null mice. Five week old female apoE null mice were given in their drinking water either no additions (water control), pravastatin 50 μg/ml, pravastatin 20 μg/ml or D-4F 2 μg/ml, or D-4F 5 μg/ml, or pravastatin (PRAVA.) 20 μg/ml together with D-4F 2 μg/ml, or pravastatin (PRAVA.) 50 μg/ml together with D-4F 5 μg/ml. After 11 weeks the mice were sacrificed and lesions determined in en face aortic preparations.

[0092] Figure 21. Pravastatin and D-4F act synergistically to reduce aortic sinus lesions in apoE null mice. Five week old female apoE null mice were given in their drinking water either no additions (water control), pravastatin 50 μg/ml, pravastatin 20 μg/ml or D-4F 2 μg/ml, or D-4F 5 μg/ml, or pravastatin (P) 50 μg/ml together with D-4F 5 μg/ml, or pravastatin (P) 20 μg/ml together with D-4F 2 μg/ml. After 11 weeks the mice were sacrificed and aortic sinus lesions were determined.

[0093] Figure 22. D-4F and SEQ ID NO:242 and SEQ ID NO:258 from Table 4 dramatically reduce lipoprotein lipid hydroperoxides in apoE null mice. Fifty μg/gm of SEQ ID NO:242 (D-198 in the drawing) or SEQ ID NO:258 (D-203 in the drawing) or D-4F (the peptides were synthesized from all D-amino acids) were added to the chow of apoE null mice or the mice were continued on chow without additions (None). Eighteen hours later the mice were bled, their plasma fractionated by FPLC and the lipid hydroperoxide (LOOH) content of their low density lipoproteins (LDL) and high density lipoproteins (HDL) were determined. *indicates p<0.01.

[0094] A peptide that "converts pro-inflammatory HDL to anti-inflammatory HDL or makes anti-inflammatory HDL more anti-inflammatory" refers to a peptide that when administered to a mammal (*e.g.* a human, a rat, a mouse, *etc.*), or that when used in an appropriate ex vivo assay (*e.g.* as described herein), converts HDL to an HDL that reduces or blocks lipid oxidation by an oxidizing agent (*e.g.* as described in USSN 6,596,544), and/or that has increased paraoxonase activity, and/or that decreases LDL-induced monocyte chemotactic activity generated by artery wall cells as compared to HDL in a control assay (*e.g.* HDL from a control animal or assay administered a lower dose of the peptide or a negative control animal or assay lacking the peptide). The alteration of HDL (conversion from non-protective to protective or increase in protective activity) is preferably a detectable change. In preferred embodiments, the change is a statistically significant change, *e.g.* as determined using any statistical test suited for the data set provided (*e.g.* t-test, analysis of variance (ANOVA), semiparametric techniques, non-parametric techniques (*e.g.* Wilcoxon Mann-Whitney Test, Wilcoxon Signed Ranks Test, Sign Test, Kruskal-Wallis Test, *etc.*). Preferably the statistically significant change is significant at least at the 85%, more preferably at least at the 90%, still more preferably at least at the 95%, and most preferably at least at the 98% or 99% confidence level. In certain embodiments, the change is at least a 10% change, preferably at least a 20% change, more preferably at least a 50% change and most preferably at least a 90% change.

DETAILED DESCRIPTION

[0095] This invention pertains to the discovery that synthetic peptides designed to mimic the class A amphipathic helical motif (Segrest *et al.* (1990) *Proteins: Structure, Function, and Genetics* 8: 103-117) are able to associate with phospholipids and exhibit many biological properties similar to human apo-A-I. In particular, it was a discovery of this invention that when such peptides are formulated using D amino acids, the peptides show dramatically elevated serum half-lives and, particularly when the amino and/or carboxy termini are blocked, can even be orally administered.

[0096] It was also a surprising discovery that these peptides can stimulate the formation and cycling of pre-beta high density lipoprotein-like particles. In addition, the peptides are capable of enhancing/synergizing the effect of statins allowing statins to be administered as significantly lower dosages or to be significantly more anti-inflammatory

at any given dose. It was also discovered that the peptides described herein can inhibit and/or prevent and/or treat one or more symptoms of osteoporosis. The peptides can also increase pre-beta HDL; and/or increase HDL paroxynase activity.

[0097] Moreover, it was a surprising discovery of this invention that such D-form peptides retain the biological activity of the corresponding L-form peptide. *In vivo* animal studies using such D-form peptides showed effective oral delivery, elevated serum half-life, and the ability to mitigate or prevent/inhibit one or more symptoms of atherosclerosis.

[0098] It was also a surprising discovery that certain small peptides consisting of a minimum of three amino acids preferentially (but not necessarily) with one or more of the amino acids being the D-sterioisomer of the amino acid, and possessing hydrophobic domains to permit lipid protein interactions, and hydrophilic domains to permit a degree of water solubility also possess significant anti-inflammatory properties. Without being bound to a particular theory, it is believed that the peptides bind the "seeding molecules" required for the formation of pro-inflammatory oxidized phospholipids such as Ox-PAPC, POVPC, PGPC, and PEIPC. Since many inflammatory conditions are mediated at least in part by oxidized lipids, we believe that the peptides of this invention are effective in ameliorating conditions that are known or suspected to be due to the formation of biologically active oxidized lipids. These include, but are not limited to atherosclerosis, rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, and osteoporosis. The "small peptides" typically range in length from 3 amino acids to about 15 amino acids, more preferably from about 4 amino acids to about 10 or 11 amino acids, and most preferably from about 4 to about 8 or 10 amino acids. The peptides are typically characterized by having hydrophobic terminal amino acids or terminal amino acids rendered hydrophobic by the attachment of one or more hydrophobic "protecting" groups. The internal structures of the peptides are described in more detail herein.

I. Stimulating the formation and cycling of pre-beta high density lipoprotein-like particles.

[0099] Reverse cholesterol transport is considered to be important in preventing the build up of lipids that predisposes to atherosclerosis (Shah *et al.* (2001) *Circulation*, 103: 3047-3050.) Many have believed the lipid of consequence is cholesterol. Our laboratory has shown that the key lipids are oxidized phospholipids that initiate the

inflammatory response in atherosclerosis (Navab *et al.*(2001) *Arterioscler Thromb Vasc Biol.*, 21(4): 481-488; Van Lenten *et al.* (001) *Trends Cardiovasc Med*, 11: 155-161; Navab M *et al.* (2001) *Circulation*, 104: 2386-2387).

[0100] This inflammatory response is also likely responsible for plaque erosion or rupture that leads to heart attack and stroke. HDL-cholesterol levels are inversely correlated with risk for heart attack and stroke (Downs *et al.* (1998) *JAMA* 279: 1615-1622; Gordon *et al.* (1977) *Am J Med.*, 62: 707-714; Castelli *et al.* (1986) *JAMA*, 256: 2835-2838).

[0101] Pre-beta HDL is generally considered to be the most active HDL fraction in promoting reverse cholesterol transport (*e.g.*, picking up cholesterol from peripheral tissues such as arteries and carrying it to the liver for excretion into the bile; see, Fielding and Fielding (2001) *Biochim Biophys Acta*, 1533(3): 175-189). However, levels of pre-beta HDL can be increased because of a failure of the pre-beta HDL to be cycled into mature alpha-migrating HDL *e.g.* LCAT deficiency or inhibition (O'Connor *et al.* (1998) *J Lipid Res*, 39: 670-678). High levels of pre-beta HDL have been reported in coronary artery disease patients (Miida *et al.* (1996) *Clin Chem.*, 42: 1992-1995).

[0102] Moreover, men have been found to have higher levels of pre-beta HDL than women but the risk of men for coronary heart disease is greater than for women (O'Connor *et al.* (1998) *J Lipid Res.*, 39: 670-678). Thus, static measurements of pre-beta HDL levels themselves are not necessarily predictive of risk for coronary artery disease. The cycling, however, of cholesterol through pre-beta HDL into mature HDL is universally considered to be protective against atherosclerosis (Fielding and Fielding (2001) *Biochim Biophys Acta*, 1533(3): 175-189). Moreover, we have demonstrated that the removal of oxidized lipids from artery wall cells through this pathway protects against LDL oxidation.

[0103] Despite relatively low absorption rates when orally administered, the peptides of this invention (*e.g.* D-4F) were highly active.

[0104] In studies of Apo-E null mice orally administered D-4F, we determined that 20 min after absorption from the intestine, D-4F forms small pre-beta HDL-like particles that contain relatively high amounts of apoA-I and paraoxonase. Indeed, estimating the amount of apoA-I in these pre-beta HDL-like particles from Western blots and comparing

the amount of apoA-I to the amount of D-4F in these particles (determined by radioactivity or LC-MRM) suggests that as D-4F is absorbed from the intestine, it acts as a catalyst causing the formation of these pre-beta HDL-like particles. This small amount of intestinally derived D-4F appears to recruit amounts of apoA-I, paraoxonase, and cholesterol into these particles that are orders of magnitude more than the amount of D-4F.

[0105] Thus, following absorption, D-4F, and other peptides of this invention, rapidly recruit relatively large amounts of apoA-I and paraoxonase to form pre-beta HDL-like particles which are very likely the most potent particles for both promoting reverse cholesterol transport and for destroying biologically active oxidized lipids. We believe that the formation of these particles and their subsequent rapid incorporation into mature HDL likely explains the dramatic reduction in atherosclerosis that we observed in LDL receptor null mice on a Western diet and in apoE-null mice on a chow diet independent of changes in plasma cholesterol or HDL-cholesterol.

[0106] Thus, in one embodiment, this invention provides methods of stimulating the formation and cycling of pre-beta high density lipoprotein-like particles by administration of one or more peptides as described herein. The peptides can thereby promote lipid transport and detoxification.

<u>II. Synergizing the activity of statins.</u>

[0107] It was also discovered that, adding a low dosage of D-4F (1 μg/ml) to the drinking water of apoE null mice for 24 hours did not significantly improve HDL function (*see, e.g.*, related application USSN 10/423,830). In addition, adding 0.05 mg/ml of atorvastatin or pravastatin alone to the drinking water of the apoE null mice for 24 hours did not improve HDL function. However, when D-4F 1 μg/ml was added to the drinking water together with 0.05 mg/ml of atorvastatin or pravastatin there was a significant improvement in HDL function). Indeed the pro-inflammatory apoE null HDL became as anti-inflammatory as 350 μg/ml of normal human HDL (h, HDL see, *e.g.*, related application USSN 10/423,830).

[0108] Thus, doses of D-4F alone, or statins alone, which by themselves had no effect on HDL function when given together acted synergistically. When D-4F and a statin were given together to apo E null mice, their pro-inflammatory HDL at 50 μg/ml of

HDL-cholesterol became as effective as normal human HDL at 350 μg/ml of HDL-cholesterol in preventing the inflammatory response induced by the action of HPODE oxidizing PAPC in cocultures of human artery wall cells.

[0109] Thus, in certain embodiments this invention provides methods for enhancing the activity of statins. The methods generally involve administering one or more peptides as described herein concurrently with one or more statins. The D-4F or other similar peptides as described herein achieve synergistic action between the statin and the orally peptide(s) to ameliorate atherosclerosis. In this context statins can be administered at significantly lower dosages thereby avoiding various harmful side effects (*e.g.* muscle wasting) associated with high dosage statin use and/or the anti-inflammatory properties of statins at any given dose are significantly enhanced.

III. Inhibiting/treating osteoporosis.

[0110] Vascular calcification and osteoporosis often co-exist in the same subjects (Ouchi *et al.* (1993) Ann NY Acad Sci., 676: 297-307; Boukhris and Becker (`1972) JAMA, 219: 1307-1311; Banks *et al.* (1994) Eur J Clin Invest., 24: 813-817; Laroche *et al.* (1994) Clin Rheumatol., 13: 611-614; Broulik and Kapitola (1993) Endocr Regul., 27: 57-60; Frye *et al.* (1992) Bone Mine., 19: 185-194; Barengolts *et al.* (1998) Calcif Tissue Int., 62: 209-213; Burnett and Vasikaran (2002) Ann Clin Biochem., 39: 203-210. Parhami *et al.* (Parhami *et al.* (1997) *Arterioscl Thromb Vasc Biol.*, 17: 680-687) demonstrated that mildly oxidized LDL (MM-LDL) and the biologically active lipids in MM-LDL [*i.e.* oxidized 1-palmitoyl-2-arachidonoyl-*sn*-glycero-3-phosphorylcholine) (Ox-PAPC)], as well as the isoprostane, 8-iso prostaglandin E_2, but not the unoxidized phospholipid (PAPC) or isoprostane 8-iso progstaglandin $F_{2\alpha}$ induced alkaline phosphatase activity and osteoblastic differentiation of calcifying vascular cells (CVCs) in vitro, but inhibited the differentiation of MC3T3-E1 bone cells.

[0111] The osteon resembles the artery wall in that the osteon is centered on an endothelial cell-lined lumen surrounded by a subendothelial space containing matrix and fibroblast-like cells, which is in turn surrounded by preosteoblasts and osteoblasts occupying a position analogous to smooth muscle cells in the artery wall (*Id.*). Trabecular bone osteoblasts also interface with bone marrow subendothelial spaces (*Id.*). Parhami *et al.* postulated that lipoproteins could cross the endothelium of bone arteries and be

deposited in the subendothelial space where they could undergo oxidation as in coronary arteries (*Id.*). Based on their *in vitro* data they predicted that LDL oxidation in the subendothelial space of bone arteries and in bone marrow would lead to reduced osteoblastic differentiation and mineralization which would contribute to osteoporosis (*Id.*). Their hypothesis further predicted that LDL levels would be positively correlated with osteoporosis as they are with coronary calcification (Pohle *et al.* (2001) *Circulation*, 104: 1927-1932) but HDL levels would be negatively correlated with osteoporosis (Parhami *et al.* (1997) *Arterioscl Thromb Vasc Biol.*, 17: 680-687).

[0112] *In vitro*, the osteoblastic differentiation of the marrow stromal cell line M2-10B4 was inhibited by MM-LDL but not native LDL (Parhami *et al.* (1999) *J Bone Miner Res.*, 14: 2067-2078). When marrow stromal cells from atherosclerosis susceptible C57BL/6 (BL6) mice fed a low fat chow diet were cultured there was robust osteogenic differentiation (*Id.*). In contrast, when the marrow stromal cells taken from the mice after a high fat, atherogenic diet were cultured they did not undergo osteogenic differentiation (*Id.*). This observation is particularly important since it provides a possible explanation for the decreased osteogenic potential of marrow stromal cells in the development of osteoporosis (Nuttall and Gimble (2000) *Bone*, 27: 177-184). *In vivo* the decrease in osteogenic potential is accompanied by an increase in adipogenesis in osteoporotic bone (*Id.*).

[0113] It was found that adding D-4F to the drinking water of apoE null mice for 6 weeks dramatically increased trabecular bone mineral density and it is believed that the other peptides of this invention will act similarly..

[0114] Our data indicate that osteoporosis can be regarded as an "atherosclerosis of bone". It appears to be a result of the action of oxidized lipids. HDL destroys these oxidized lipids and promotes osteoblastic differentiation. Our datat indicate that administering peptide(s) of this invention to a mammal (*e.g.* in the drinking water of apoE null mice) dramatically increases trabecular bone in just a matter of weeks.

[0115] This indicates that the peptides described herein are useful for mitigation one or more symptoms of atherosclerosis (*e.g.* for inhibiting decalcification) or for inducing recalcification of osteoporotic bone. The peptides are also useful as

prophylactics to prevent the onset of symptom(s) of osteoporosis in a mammal (*e.g.* a patient at risk for osteoporosis).

IV. Mitigation of a symptom of atherosclerosis.

[0116] We discovered that normal HDL inhibits three steps in the formation of mildly oxidized LDL. In those studies (*see,* copending application USSN 09/541,468, filed on March 31, 2000) we demonstrated that treating human LDL *in vitro* with apo A-I or an apo A-I mimetic peptide (37pA) removed seeding molecules from the LDL that included HPODE and HPETE. These seeding molecules were required for cocultures of human artery wall cells to be able to oxidize LDL and for the LDL to induce the artery wall cells to produce monocyte chemotactic activity. We also demonstrated that after injection of apo A-I into mice or infusion into humans, the LDL isolated from the mice or human volunteers after injection/infusion of apo A-I was resistant to oxidation by human artery wall cells and did not induce monocyte chemotactic activity in the artery wall cell cocultures.

[0117] The protective function of the D peptides of this invention is illustrated in the parent applications (09/645,454, filed August 24, 2000, 09/896,841, filed June 29, 2001, and WO 02/15923 (PCT/US01/26497), filed June 29, 2001, *see, e.g.,* Figures 1-5 in WO 02/15923. Figure 1, panels A, B, C, and D in WO 02/15923 show the association of ^{14}C-D-5F with blood components in an ApoE null mouse. It is also demonstrated that HDL from mice that were fed an atherogenic diet and injected with PBS failed to inhibit the oxidation of human LDL and failed to inhibit LDL-induced monocyte chemotactic activity in human artery wall coculures. In contrast, HDL from mice fed an atherogenic diet and injected daily with peptides described herein was as effective in inhibiting human LDL oxidation and preventing LDL-induced monocyte chemotactic activity in the cocultures as was normal human HDL (Figures 2A and 2B in WO 02/15923). In addition, LDL taken from mice fed the atherogenic diet and injected daily with PBS was more readily oxidized and more readily induced monocyte chemotactic activity than LDL taken from mice fed the same diet but injected with 20 μg daily of peptide 5F. The D peptide did not appear to be immunogenic (Figure 4 in WO 02/15923).

[0118] The *in vitro* responses of human artery wall cells to HDL and LDL from mice fed the atherogenic diet and injected with a peptide according to this invention are

consistent with the protective action shown by such peptides *in vivo*. Despite, similar levels of total cholesterol, LDL-cholesterol, IDL+VLDL-cholesterol, and lower HDL-cholesterol as a percent of total cholesterol, the animals fed the atherogenic diet and injected with the peptide had significantly lower lesion scores (Figure 5 in WO 02/15923). The peptides of this invention thus prevented progression of atherosclerotic lesions in mice fed an atherogenic diet.

[0119] Thus, in one embodiment, this invention provides methods for ameliorating and/or preventing one or more symptoms of atherosclerosis.

VI. Mitigation of a symptom of atheroscloerosis associated with an acute inflammatory response.

[0120] The peptides of this invention are also useful in a number of contexts. For example, we have observed that cardiovascular complications (*e.g.* atherosclerosis, stroke, *etc.*) frequently accompany or follow the onset of an acute phase inflammatory response. Such an acute phase inflammatory response is often associated with a recurrent inflammatory disease (*e.g.,* leprosy, tuberculosis, systemic lupus erythematosus, and rheumatoid arthritis), a viral infection (*e.g.* influenza), a bacterial infection, a fungal infection, an organ transplant, a wound or other trauma, an implanted prosthesis, a biofilm, and the like.

[0121] It was a surprising discovery of this invention that administration of one or more of the peptides described herein, can reduce or prevent the formation of oxidized phospholipids during or following an acute phase response and thereby mitigate or eliminate cardiovascular complications associated with such a condition.

[0122] Thus, for example, we have demonstrated that a consequence of influenza infection is the diminution in paraoxonase and platelet activating acetylhydrolase activity in the HDL. Without being bound by a particular theory, we believe that, as a result of the loss of these HDL enzymatic activities and also as a result of the association of pro-oxidant proteins with HDL during the acute phase response, HDL is no longer able to prevent LDL oxidation and was no longer able to prevent the LDL-induced production of monocyte chemotactic activity by endothelial cells.

[0123] We observed that in a subject injected with very low dosages of the polypeptides of this invention (*e.g.* 20 micrograms for mice) daily after infection with the influenza A virus paraoxonase levels did not fall and the biologically active oxidized phospholipids were not generated beyond background. This indicates that D-4F (and/or other peptides of this invention) can be administered (*e.g.* orally or by injection) to patients with known coronary artery disease during influenza infection or other events that can generate an acute phase inflammatory response (*e.g.* due to viral infection, bacterial infection, trauma, transplant, various autoimmune conditions, *etc.*) and thus we can prevent by this short term treatment the increased incidence of heart attack and stroke associated with pathologies that generate such inflammatory states.

[0124] Thus, in certain embodiments, this invention contemplates administering one or more of the peptides of this invention to a subject at risk for, or incurring, an acute inflammatory response and/or at risk for or incurring a symptom of atherosclerosis.

[0125] Thus, for example, a person having or at risk for coronary disease may prophylactically be administered a polypeptide of this invention during flu season. A person (or animal) subject to a recurrent inflammatory condition, *e.g.* rheumatoid arthritis, various autoimmune diseases, *etc.,* can be treated with a polypeptide of this invention to mitigate or prevent the development of atherosclerosis or stroke. A person (or animal) subject to trauma, *e.g.* acute injury, tissue transplant, *etc.* can be treated with a polypeptide of this invention to mitigate the development of atherosclerosis or stroke.

[0126] In certain instances such methods will entail a diagnosis of the occurrence or risk of an acute inflammatory response. The acute inflammatory response typically involves alterations in metabolism and gene regulation in the liver. It is a dynamic homeostatic process that involves all of the major systems of the body, in addition to the immune, cardiovascular and central nervous system. Normally, the acute phase response lasts only a few days; however, in cases of chronic or recurring inflammation, an aberrant continuation of some aspects of the acute phase response may contribute to the underlying tissue damage that accompanies the disease, and may also lead to further complications, for example cardiovascular diseases or protein deposition diseases such as amyloidosis.

[0127] An important aspect of the acute phase response is the radically altered biosynthetic profile of the liver. Under normal circumstances, the liver synthesizes a

characteristic range of plasma proteins at steady state concentrations. Many of these proteins have important functions and higher plasma levels of these acute phase reactants (APRs) or acute phase proteins (APPs) are required during the acute phase response following an inflammatory stimulus. Although most APRs are synthesized by hepatocytes, some are produced by other cell types, including monocytes, endothelial cells, fibroblasts and adipocytes. Most APRs are induced between 50% and several-fold over normal levels. In contrast, the major APRs can increase to 1000-fold over normal levels. This group includes serum amyloid A (SAA) and either C-reactive protein (CRP) in humans or its homologue in mice, serum amyloid P component (SAP). So-called negative APRs are decreased in plasma concentration during the acute phase response to allow an increase in the capacity of the liver to synthesize the induced APRs.

[0128] In certain embodiments, the acute phase response, or risk therefore is evaluated by measuring one or more APPs. Measuring such markers is well known to those of skill in the art, and commercial companies exist that provide such measurement (*e.g.* AGP measured by Cardiotech Services, Louisville, KY).

VII. Mitigation of a symptom or condition associated with coronary calcification and osteoporosis.

[0129] We have also identified oxidized lipids as a cause of coronary calcification and osteoporosis. Moreover, without being bound to a particularly theory, we believe the same mechanisms are involved in the pathogenesis of calcific aortic stenosis.

[0130] Thus, in certain embodiments, this invention contemplates the use of the peptides described herein to inhibit or prevent a symptom of a disease such as polymyalgia rheumatica, polyarteritis nodosa, scleroderma, lupus erythematosus, idiopathic pulmonary fibrosis, chronic obstructive pulmonary disease, Alzheimers Disease, AIDS, coronary calcification, calcific aortic stenosis, osteoporosis, and the like.

V. Peptide Administration.

[0131] The methods of this invention typically involve administering to an organism, preferably a mammal, more preferably a human one or more of the peptides of this invention (or mimetics of such peptides). The peptide(s) can be administered, as described herein, according to any of a number of standard methods including, but not

limited to injection, suppository, nasal spray, time-release implant, transdermal patch, and the like. In one particularly preferred embodiment, the peptide(s) are administered orally (*e.g.* as a syrup, capsule, or tablet).

[0132] The methods can involve the administration of a single peptide of this invention or the administration of two or more different peptides. The peptides can be provided as monomers or in dimeric, oligomeric or polymeric forms. In certain embodiments, the multimeric forms may comprise associated monomers (*e.g.* ionically or hydrophobically linked) while certain other multimeric forms comprise covalently linked monomers (directly linked or through a linker).

[0133] While the invention is described with respect to use in humans, it is also suitable for animal, *e.g.* veterinary use. Thus preferred organisms include, but are not limited to humans, non-human primates, canines, equines, felines, porcines, ungulates, largomorphs, and the like.

[0134] The methods of this invention are not limited to humans or non-human animals showing one or more symptom(s) of atherosclerosis (*e.g.* hypertension, plaque formation and rupture, reduction in clinical events such as heart attack, angina, or stroke, high levels of plasma cholesterol, high levels of low density lipoprotein, high levels of very low density lipoprotein, or inflammatory proteins such as CRP, *etc.*), but are useful in a prophylactic context. Thus, the peptides of this invention (or mimetics thereof) may be administered to organisms to prevent the onset/development of one or more symptoms of atherosclerosis. Particularly preferred subjects in this context are subjects showing one or more risk factors for atherosclerosis (*e.g.* family history, hypertension, obesity, high alcohol consumption, smoking, high blood cholesterol, high blood triglycerides, elevated blood LDL, VLDL, IDL, or low HDL, diabetes, or a family history of diabetes, high blood lipids, heart attack, angina or stroke, *etc.*).

[0135] The peptides of this invention can also be administered to stimulate the formation and cycling of pre-beta high density lipoprotein-like particles and/or to promote reverse lipid transport and detoxification.

[0136] The peptides are also useful for administration with statins where they enhance (*e.g.*, synergize) the activity of the statin and permit the statin(s) to be

administered at lower dosages and/or the anti-inflammatory properties of statins at any given dose are significantly enhanced.

[0137] In addition, the peptides can be administered to reduce or eliminate one or more symptoms of osteoporosis and/or to prevent/inhibit the onset of one or more symptoms of osteoporosis.

VIII. Preferred peptides and their preparation.

A) Class A amphipathic helical peptides.

[0138] It was a discovery of this invention that peptides comprising a class A amphipathic helix ("class A peptides"), are capable of mitigating one or more symptoms of atherosclerosis. Class A peptides are characterized by formation of an α-helix that produces a segregation of polar and non-polar residues thereby forming a polar and a nonpolar face with the positively charged residues residing at the polar-nonpolar interface and the negatively charged residues residing at the center of the polar face (*see, e.g.*, Anantharamaiah (1986) *Meth. Enzymol*, 128: 626-668). It is noted that the fourth exon of apo A-I, when folded into 3.667 residues/turn produces a class A amphipathic helical structure.

[0139] One particularly preferred class A peptide, designated 18A (*see, e.g.*, Anantharamaiah (1986) *Meth. Enzymol*, 128: 626-668) was modified as described herein to produce peptides orally administratable and highly effective at inhibiting or preventing one or more symptoms of atherosclerosis. Without being bound by a particular theory, it is believed that the peptides of this invention act *in vivo* may by picking up seeding molecule(s) that mitigate oxidation of LDL.

[0140] We determined that increasing the number of Phe residues on the hydrophobic face of 18A would theoretically increase lipid affinity as determined by the computation described by Palgunachari *et al.* (1996) *Arteriosclerosis, Thrombosis, & Vascular Biology* 16: 328-338. Theoretically, a systematic substitution of residues in the nonpolar face of 18A with Phe could yield six peptides. Peptides with an additional 2, 3 and 4 Phe would have theoretical lipid affinity (λ) values of 13, 14 and 15 units, respectively. However, the λ values jumped four units if the additional Phe were increased

from 4 to 5 (to 19 λ units). Increasing to 6 or 7 Phe would produce a less dramatic increase (to 20 and 21 λ units, respectively). Therefore, we chose 5 additional Phe (and hence the peptides designation as 5F). In one particularly preferred embodiment, the 5F peptide was blocked in that the amino terminal residue was acetylated and the carboxyl terminal residue was amidated.

[0141] The new class A peptide analog, 5F, inhibited lesion development in atherosclerosis-susceptible mice. The new peptide analog, 5F, was compared with mouse apo A-I (MoA-I) for efficacy in inhibiting diet-induced atherosclerosis in these mice using peptide dosages based on the study by Levine *et al.* (Levine *et al.* (1993) *Proc. Natl. Acad. Sci.* USA 90:12040-12044).

[0142] A number of other class A peptides were also produced and showed varying, but significant degrees of efficacy in mitigating one or more symptoms of atherosclerosis. A number of such peptides are illustrated in Table 1.

[0143] Table 1. Illustrative mimetics of the amphipathic helix of Apo A-I for use in this invention.

Peptide Name	Amino Acid Sequence	SEQ ID NO.
18A	D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F	4
2F	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH_2	5
3F	Ac-D-W-F-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH_2	6
3F14	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2	7
4F	Ac-D-W-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2	8
5F	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	9
6F	Ac-D-W-L-K-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH_2	10
7F	Ac-D-W-F-K-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH_2	11
	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH_2	12
	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH_2	13
	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH_2	14
	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH_2	15
	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	16
	Ac-E-W-L-K-L-F-Y-E-K-V-L-E-K-F-K-E-A-F-NH_2	17
	Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2	18
	Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH_2	19

Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH_2 20
Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH_2 21
Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH_2 22
Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2 23
AC-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH_2 24
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2 25
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2 26
Ac-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH_2 27
Ac-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH_2 28
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2 29
Ac-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH_2 30
Ac-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH_2 31
Ac-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH_2 32
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH_2 33
Ac-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-NH_2 34
Ac-L-F-Y-E-K-V-L-E-K-F-K-E-A-F-NH_2 35
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2 36
Ac-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH_2 37
Ac-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH_2 38
Ac-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH_2 39
Ac-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH_2 40
Ac-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2 41
Ac-D-W-L-K-A-L-Y-D-K-V-A-E-K-L-K-E-A-L-NH_2 42
Ac-D-W-F-K-A-F-Y-E-K-V-A-E-K-L-K-E-F-F-NH_2 43
Ac-D-W-F-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH_2 44
Ac-E-W-L-K-A-L-Y-E-K-V-A-E-K-L-K-E-A-L-NH_2 45
Ac-E-W-L-K-A-F-Y-E-K-V-A-E-K-L-K-E-A-F-NH_2 46
Ac-E-W-F-K-A-F-Y-E-K-V-A-E-K-L-K-E-F-F-NH_2 47
Ac-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH_2 48
Ac-E-W-L-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH_2 49
Ac-E-W-F-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH_2 50
Ac-D-F-L-K-A-W-Y-D-K-V-A-E-K-L-K-E-A-W-NH_2 51
Ac-E-F-L-K-A-W-Y-E-K-V-A-E-K-L-K-E-A-W-NH_2 52
Ac-D-F-W-K-A-W-Y-D-K-V-A-E-K-L-K-E-W-W-NH_2 53
Ac-E-F-W-K-A-W-Y-E-K-V-A-E-K-L-K-E-W-W-NH_2 54
Ac-D-K-L-K-A-F-Y-D-K-V-F-E-W-A-K-E-A-F-NH_2 55
Ac-D-K-W-K-A-V-Y-D-K-F-A-E-A-F-K-E-F-L-NH_2 56
Ac-E-K-L-K-A-F-Y-E-K-V-F-E-W-A-K-E-A-F-NH_2 57
Ac-E-K-W-K-A-V-Y-E-K-F-A-E-A-F-K-E-F-L-NH_2 58

Ac-D-W-L-K-A-F-V-D-K-F-A-E-K-F-K-E-A-Y-NH_2 59

Ac-E-K-W-K-A-V-Y-E-K-F-A-E-A-F-K-E-F-L-NH_2 60

Ac-D-W-L-K-A-F-V-Y-D-K-V-F-K-L-K-E-F-F-NH_2 61

Ac-E-W-L-K-A-F-V-Y-E-K-V-F-K-L-K-E-F-F-NH_2 62

Ac-D-W-L-R-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH_2 63

Ac-E-W-L-R-A-F-Y-E-K-V-A-E-K-L-K-E-A-F-NH_2 64

Ac-D-W-L-K-A-F-Y-D-R-V-A-E-K-L-K-E-A-F-NH_2 65

Ac-E-W-L-K-A-F-Y-E-R-V-A-E-K-L-K-E-A-F-NH_2 66

Ac-D-W-L-K-A-F-Y-D-K-V-A-E-R-L-K-E-A-F-NH_2 67

Ac-E-W-L-K-A-F-Y-E-K-V-A-E-R-L-K-E-A-F-NH_2 68

Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-R-E-A-F-NH_2 69

Ac-E-W-L-K-A-F-Y-E-K-V-A-E-K-L-R-E-A-F-NH_2 70

Ac-D-W-L-K-A-F-Y-D-R-V-A-E-R-L-K-E-A-F-NH_2 71

Ac-E-W-L-K-A-F-Y-E-R-V-A-E-R-L-K-E-A-F-NH_2 72

Ac-D-W-L-R-A-F-Y-D-K-V-A-E-K-L-R-E-A-F-NH_2 73

Ac-E-W-L-R-A-F-Y-E-K-V-A-E-K-L-R-E-A-F-NH_2 74

Ac-D-W-L-R-A-F-Y-D-R-V-A-E-K-L-K-E-A-F-NH_2 75

Ac-E-W-L-R-A-F-Y-E-R-V-A-E-K-L-K-E-A-F-NH_2 76

Ac-D-W-L-K-A-F-Y-D-K-V-A-E-R-L-R-E-A-F-NH_2 77

Ac-E-W-L-K-A-F-Y-E-K-V-A-E-R-L-R-E-A-F-NH_2 78

Ac-D-W-L-R-A-F-Y-D-K-V-A-E-R-L-K-E-A-F-NH_2 79

Ac-E-W-L-R-A-F-Y-E-K-V-A-E-R-L-K-E-A-F-NH2 80

D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F**-P-**D-W-
L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F 81

D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F**-P-**D-W-
L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F 82

D-W-F-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F**-P-**D-W-
F-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F 83

D-K-L-K-A-F-Y-D-K-V-F-E-W-A-K-E-A-F**-P-**D-K-
L-K-A-F-Y-D-K-V-F-E-W-L-K-E-A-F 84

D-K-W-K-A-V-Y-D-K-F-A-E-A-F-K-E-F-L**-P-**D-K-
W-K-A-V-Y-D-K-F-A-E-A-F-K-E-F-L 85

D-W-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F**-P-**D-W-
F-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F 86

D-W-L-K-A-F-V-Y-D-K-V-F-K-L-K-E-F-F**-P-**D-W-
L-K-A-F-V-Y-D-K-V-F-K-L-K-E-F-F 87

D-W-L-K-A-F-Y-D-K-F-A-E-K-F-K-E-F-F**-P-**D-W-
L-K-A-F-Y-D-K-F-A-E-K-F-K-E-F-F 88

Ac-E-W-F-K-A-F-Y-E-K-V-A-E-K-F-K-E-A-F-NH_2 89

Ac-D-W-F-K-A-F-Y-D-K-V-A-E-K-F-NH_2 90

Ac-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-NH_2 91

Ac-F-K-A-F-Y-E-K-V-A-E-K-F-K-E-NH_2	92
NMA-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-NH_2	93
NMA-F-K-A-F-Y-E-K-V-A-E-K-F-K-E-NH_2	94
NMA-D-W-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2	95
NMA-E-W-F-K-A-F-Y-E-K-V-A-E-K-F-K-E-A-F-NH_2	96
NMA-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH_2	97
NMA-D-W-F-K-A-F-Y-D-K-V-A-E-K-F-NH_2	98
Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	99
NMA-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	
Ac-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH_2	100
NMA-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH_2	
Ac-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	101
NMA-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH_2	
Ac-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH_2	102
NMA-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH_2	
Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-NH_2	103
NMA-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-NH_2	
Ac-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-NH_2	104
NMA-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-NH_2	
Ac-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-NH_2	105
NMA -L-K-A-F-Y-D-K-V-F-E-K-F-K-E-NH_2	
Ac-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-NH_2	106
NMA-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-NH_2	

[1]Linkers are underlined.

NMA is N-Methyl Anthranilyl.

[0144] In certain preferred embodiments, the peptides include variations of 4F or D-4F where one or both aspartic acids (D) are replaced by glutamic acid (E). Also contemplated are peptides (*e.g.* 4F or D-4F) where 1, 2, 3, or 4 amino acids are deleted from the carboxyl terminus and/or 1, 2, 3, or 4 amino acids are deleted from the carboxyl terminus and/or one or both aspartic acids (D) are replaced by glutamic acid (E). In any of the peptides described herein, the N-terminus can be blocked and labeled using a mantyl moiety (*e.g.* N-methylanthranilyl).

[0145] While various peptides of Table 1, are illustrated with an acetyl group or an N-methylanthranilyl group protecting the amino terminus and an amide group protecting the carboxyl terminus, any of these protecting groups may be eliminated and/or substituted

with another protecting group as described herein. In particularly preferred embodiments, the peptides comprise one or more D-form amino acids as described herein. In certain embodiments, every amino acid (*e.g.* every enantiomeric amino acid) of the peptides of Table 1 is a D-form amino acid.

[0146] It is also noted that Table Table 1 is not fully inclusive. Using the teaching provided herein, other suitable class A amphipathic helical peptides can routinely be produced (*e.g.* by conservative or semi-conservative substitutions (*e.g.* D replaced by E), extensions, deletions, and the like). Thus, for example, one embodiment utilizes truncations of any one or more of peptides shown hwerein (*e.g.* peptides identified by SEQ ID Nos:5-23 and 42- in Table 1). Thus, for example, SEQ ID NO:24 illustrates a peptide comprising 14 amino acids from the C-terminus of 18A comprising one or more D amino acids, while SEQ ID NOS:25-41 illustrate other truncations.

[0147] Longer peptides are also suitable. Such longer peptides may entirely form a class A amphipathic helix, or the class A amphipathic helix (helices) can form one or more domains of the peptide. In addition, this invention contemplates multimeric versions of the peptides. Thus, for example, the peptides illustrated heren can be coupled together (directly or through a linker (*e.g.* a carbon linker, or one or more amino acids) with one or more intervening amino acids). Illustrative polymeric peptides include 18A-Pro-18A and the peptides of SEQ ID NOs:81-88, in certain embodiments comprising one or more D amino acids, more preferably with every amino acid a D amino acid as described herein and/or having one or both termini protected.

B) Other class A amphipathic helical peptide mimetics of apoA-I having Aromatic or aliphatic residues in the non-polar face.

[0148] In certain embodiments, this invention also provides modified class A amphiphathic helix peptides. Certain preferred peptides incorporate one or more aromatic residues at the center of the nonpolar face, *e.g.* $3F^{C\pi}$, (as present in 4F), or with one or more aliphatic residues at the center of the nonpolar face, *e.g.* $3F^{I\pi}$. Without being bound to a particular theory, we believe the central aromatic residues on the nonpolar face of the peptide $3F^{C\pi}$, due to the presence of π electrons at the center of the nonpolar face, allow water molecules to penetrate near the hydrophobic lipid alkyl chains of the peptide-lipid

complex, which in turn would enable the entry of reactive oxygen species (such as lipid hydroperoxides) shielding them from the cell surface. Similarly, we also believe the peptides with aliphatic residues at the center of the nonpolar face, *e.g.* $3F^{I\pi}$, will act similarly but not quite as effectively as $3F^{C\pi}$.

[0149] Preferred peptides will convert pro-inflammatory HDL to anti-inflammatory HDL or make anti-inflammatory HDL more anti-inflammatory, and/or decrease LDL-induced monocyte chemotactic activity generated by artery wall cells equal to or greater than D4F or other peptides shown in Table 1. Peptides showing this activity are useful in ameliorating atherosclerosis and other inflammatory conditions such as rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, osteoporosis, Alzheimer's disease, congestive heart failure, endothelial dysfunction, and viral illnesses such as influenza A and diseases such as multiple sclerosis.

[0150] Table 2. Examples of certain preferred peptides.

Name	Sequence	SEQ ID NO
($3F^{C\pi}$)	Ac-DKWKAVYDKFAEAFKEFL-NH_2	107
($3F^{I\pi}$)	Ac-DKLKAFYDKVFEWAKEAF-NH_2	108

C) Smaller peptides.

[0151] It was also a surprising discovery that certain small peptides consisting of a minimum of three amino acids preferentially (but not necessarily) with one or more of the amino acids being the D-sterioisomer of the amino acid, and possessing hydrophobic domains to permit lipid protein interactions, and hydrophilic domains to permit a degree of water solubility also possess significant anti-inflammatory properties. Without being bound to a particular theory, it is believed that the peptides bind the "seeding molecules" required for the formation of pro-inflammatory oxidized phospholipids such as Ox-PAPC, POVPC, PGPC, and PEIPC. Since many inflammatory conditions are mediated at least in part by oxidized lipids, we believe that the peptides of this invention are effective in ameliorating conditions that are known or suspected to be due to the formation of biologically active oxidized lipids. These include, but are not limited to atherosclerosis, rheumatoid arthritis, lupus erythematous, polyarteritis nodosa, and osteoporosis. The

"small peptides" typically range in length from 3 amino acids to about 15 amino acids, more preferably from about 4 amino acids to about 10 or 11 amino acids, and most preferably from about 4 to about 8 or 10 amino acids. The peptides are typically characterized by having hydrophobic terminal amino acids or terminal amino acids rendered hydrophobic by the attachment of one or more hydrophobic "protecting" groups.

[0152] In certain embodiments, the peptides can be characterized by Formula I, below:

$$X^1\text{-}X^2\text{-}X^3{}_n\text{-}X^4 \qquad \text{I}$$

where, n is 0 or 1, X^1 is a hydrophobic amino acid and/or bears a hydrophobic protecting group, X^4 is a hydrophobic amino acid and/or bears a hydrophobic protecting group; and when n is 0 X^2 is an acidic or a basic amino acid; when n is 1: X^2 and X^3 are independently an acidic amino acid, a basic amino acid, an aliphatic amino acid, or an aromatic amino acid such that when X^2 is an acidic amino acid; X^3 is a basic amino acid, an aliphatic amino acid, or an aromatic amino acid; when X^2 is a basic amino acid; X^3 is an acidic amino acid, an aliphatic amino acid, or an aromatic amino acid; and when X^2 is an aliphatic or aromatic amino acid, X^3 is an acidic amino acid, or a basic amino acid.

[0153] Longer peptides (*e.g.* up to 10, 11, or 15 amino acids)are also contemplated within the scope of this invention. Typcially where the shorter peptides (*e.g.* peptides according to formula I) are characterized by an acidic, basic, aliphatic, or aromatic amino acid, the longer peptides are characterized by acidic, basic, aliphatic, or aromatic domains comprising two or more amino acids of that type.

1) Tripeptides.

[0154] It was discovered that certain tripeptides (3 amino acid peptides) can be synthesized that show desirable properties as described herein (*e.g.* the ability to convert pro-inflammatory HDL to anti-inflammatory HDL, the ability to decrease LDL-induced monocyte chemotactic activity generated by artery wall cells, the ability to increase pre-beta HDL, *etc.*). In certain embodiments, the peptides are characterized by formula I, wherein N is zero, shown below as Formula II:

$$X^1\text{-}X^2\text{-}X^4 \qquad \text{II}$$

where the end amino acids (X^1 and X^4) are hydrophobic either because of a hydrophobic side chain or because the side chain or the C and/or N terminus is blocked with one or more hydrophobic protecting group(s) (*e.g.*, the N-terminus is blocked with Boc-, Fmoc-, Nicotinyl-, *etc.*, and the C-terminus blocked with (*t*Bu)-O*t*Bu, *etc.*). In certain embodiments, the X^2 amino acid is either acidic (*e.g.* aspartic acid, glutamic acid, *etc.*) or basic (*e.g.* histidine, arginine, lysine, *etc.*). The peptide can be all L- amino acids or include one or more or all D-amino acids.

[0155] Certain preferred tripeptides of this invention include, but are not limited to the peptides shown in Table 3.

[0156] Table 3. Examples of certain preferred tripeptides bearing hydrophobic blocking groups and acidic, basic, or histidine central amino acids.

X^1	X^2	X^3	X^4	SEQ ID NO
Boc-Lys(εBoc)	Arg		Ser(*t*Bu)-O*t*Bu	109
Boc-Lys(εBoc)	Arg		Thr(*t*Bu)-O*t*Bu	110
Boc-Trp	Arg		Ile-O*t*Bu	111
Boc-Trp	Arg		Leu-O*t*Bu	112
Boc-Phe	Arg		Ile –O*t*Bu	113
Boc-Phe	Arg		Leu-O*t*Bu	114
Boc-Lys(εBoc)	Glu		Ser(*t*Bu)-O*t*Bu	115
Boc-Lys(εBoc)	Glu		Thr(*t*Bu)-O*t*Bu	116
Boc-Lys(εBoc)	Asp		Ser(*t*Bu)-O*t*Bu	117
Boc-Lys(εBoc)	Asp		Thr(*t*Bu)-O*t*Bu	118
Boc-Lys(εBoc)	Arg		Ser(*t*Bu)-O*t*Bu	119
Boc-Lys(εBoc)	Arg		Thr(*t*Bu)-O*t*Bu	120
Boc-Leu	Glu		Ser(*t*Bu)-O*t*Bu	121
Boc-Leu	Glu		Thr(*t*Bu)-O*t*Bu	122
Fmoc-Trp	Arg		Ser(*t*Bu)-O*t*Bu	123
Fmoc-Trp	Asp		Ser(*t*Bu)-O*t*Bu	124
Fmoc-Trp	Glu		Ser(*t*Bu)-O*t*Bu	125
Fmoc-Trp	Arg		Ser(*t*Bu)-O*t*Bu	126
Boc-Lys(εBoc)	Glu		Leu-*Ot*Bu	127
Fmoc-Leu	Arg		Ser(*t*Bu)-O*t*Bu	128
Fmoc-Leu	Asp		Ser(*t*Bu)-O*t*Bu	129
Fmoc-Leu	Glu		Ser(*t*Bu)-O*t*Bu	130

Fmoc-Leu	Arg	Ser(*t*Bu)-O*t*Bu	131
Fmoc-Leu	Arg	Thr(*t*Bu)-O*t*Bu	132
Boc-Glu	Asp	Tyr(*t*Bu)-O*t*Bu	133
Fmoc-Lys(εFmoc)	Arg	Ser(*t*Bu)-O*t*Bu	134
Fmoc-Trp	Arg	Ile-O*t*Bu	135
Fmoc-Trp	Arg	Leu-O*t*Bu	136
Fmoc-Phe	Arg	Ile-O*t*Bu	137
Fmoc-Phe	Arg	Leu-O*t*Bu	138
Boc-Trp	Arg	Phe-O*t*Bu	139
Boc-Trp	Arg	Tyr-O*t*Bu	140
Fmoc-Trp	Arg	Phe-O*t*Bu	141
Fmoc-Trp	Arg	Tyr-O*t*Bu	142
Boc-Orn(δBoc)	Arg	Ser(*t*Bu)-O*t*Bu	143
Nicotinyl Lys(εBoc)	Arg	Ser(*t*Bu)-O*t*Bu	144
Nicotinyl Lys(εBoc)	Arg	Thr(*t*Bu)-O*t*Bu	145
Fmoc-Leu	Asp	Thr(*t*Bu)-OtBu	146
Fmoc-Leu	Glu	Thr(*t*Bu)-OtBu	147
Fmoc-Leu	Arg	Thr(*t*Bu)-OtBu	148
Fmoc-norLeu	Arg	Ser(*t*Bu)-OtBu	149
Fmoc-norLeu	Asp	Ser(*t*Bu)-OtBu	150
Fmoc-norLeu	Glu	Ser(*t*Bu)-OtBu	151
Fmoc-Lys(εBoc)	Arg	Ser(*t*Bu)-OtBu	152
Fmoc-Lys(εBoc)	Arg	Thr(*t*Bu)-OtBu	153
Fmoc-Lys(εBoc)	Glu	Ser(*t*Bu)-OtBu	154
Fmoc-Lys(εBoc)	Glu	Thr(*t*Bu)-OtBu	155
Fmoc-Lys(εBoc)	Asp	Ser(*t*Bu)-OtBu	156
Fmoc-Lys(εBoc)	Asp	Thr(*t*Bu)-OtBu	157
Fmoc-Lys(εBoc)	Glu	Leu-*OtBu*	158
Fmoc-Lys(εBoc)	Arg	Leu-*OtBu*	159
Fmoc-Lys(εFmoc)	Arg	Thr(*t*Bu)-OtBu	160
Fmoc- Lys(εFmoc)	Glu	Ser(*t*Bu)-OtBu	161
Fmoc- Lys(εFmoc)	Glu	Thr(*t*Bu)-OtBu	162
Fmoc- Lys(εFmoc)	Asp	Ser(*t*Bu)-OtBu	163
Fmoc- Lys(εFmoc)	Asp	Thr(*t*Bu)-OtBu	164
Fmoc- Lys(εFmoc)	Arg	Ser(*t*Bu)-OtBu	165
Fmoc- Lys(εFmoc))	Glu	Leu-*OtBu*	166
Boc-Lys(εFmoc)	Asp	Ser(*t*Bu)-OtBu	167
Boc-Lys(εFmoc)	Asp	Thr(*t*Bu)-OtBu	168
Boc-Lys(εFmoc)	Arg	Thr(*t*Bu)-OtBu	169
Boc-Lys(εFmoc)	Glu	Leu-*OtBu*	170
Boc-Orn(δFmoc)	Glu	Ser(*t*Bu)-OtBu	171

Boc-Orn(δFmoc)	Asp	Ser(*t*Bu)-OtBu	172
Boc-Orn(δFmoc)	Asp	Thr(*t*Bu)-OtBu	173
Boc-Orn(δFmoc)	Arg	Thr(*t*Bu)-OtBu	174
Boc-Orn(δFmoc)	Glu	Thr(*t*Bu)-OtBu	175
Fmoc-Trp	Asp	Ile-OtBu	176
Fmoc-Trp	Arg	Ile-OtBu	177
Fmoc-Trp	Glu	Ile-OtBu	178
Fmoc-Trp	Asp	Leu-OtBu	179
Fmoc-Trp	Glu	Leu-OtBu	180
Fmoc-Phe	Asp	Ile-OtBu	181
Fmoc-Phe	Asp	Leu-OtBu	182
Fmoc-Phe	Glu	Leu-OtBu	183
Fmoc-Trp	Arg	Phe-OtBu	184
Fmoc-Trp	Glu	Phe-OtBu	185
Fmoc-Trp	Asp	Phe-OtBu	186
Fmoc-Trp	Asp	Tyr-OtBu	187
Fmoc-Trp	Arg	Tyr-OtBu	188
Fmoc-Trp	Glu	Tyr-OtBu	189
Fmoc-Trp	Arg	Thr(*t*Bu)-OtBu	190
Fmoc-Trp	Asp	Thr(*t*Bu)-OtBu	191
Fmoc-Trp	Glu	Thr(*t*Bu)-OtBu	192
Boc-Phe	Arg	norLeu-OtBu	193
Boc-Phe	Glu	norLeu-OtBu	194
Fmoc-Phe	Asp	norLeu-OtBu	195
Boc-Glu	His	Tyr(*t*Bu)-O*t*Bu	196
Boc-Leu	His	Ser(*t*Bu)-O*t*Bu	197
Boc-Leu	His	Thr(*t*Bu)-O*t*Bu	198
Boc-Lys(εBoc)	His	Ser(*t*Bu)-O*t*Bu	199
Boc-Lys(εBoc)	His	Thr(*t*Bu)-O*t*Bu	200
Boc-Lys(εBoc)	His	Leu-*Ot*Bu	201
Boc-Lys(εFmoc)	His	Ser(*t*Bu)-OtBu	202
Boc-Lys(εFmoc)	His	Thr(*t*Bu)-OtBu	203
Boc-Lys(εFmoc)	His	Leu-*OtBu*	204
Boc-Orn(δBoc)	His	Ser(*t*Bu)-O*t*Bu	205
Boc-Orn(δFmoc)	His	Thr(*t*Bu)-OtBu	206
Boc-Phe	His	Ile –O*t*Bu	207
Boc-Phe	His	Leu-O*t*Bu	208
Boc-Phe	His	norLeu-OtBu	209

Boc-Phe	Lys	Leu-O*t*Bu	210
Boc-Trp	His	Ile-O*t*Bu	211
Boc-Trp	His	Leu-O*t*Bu	212
Boc-Trp	His	Phe-O*t*Bu	213
Boc-Trp	His	Tyr-O*t*Bu	214
Boc-Phe	Lys	Leu-O*t*Bu	215
Fmoc- Lys(εFmoc)	His	Ser(*t*Bu)-OtBu	216
Fmoc- Lys(εFmoc)	His	Thr(*t*Bu)-OtBu	217
Fmoc- Lys(εFmoc))	His	Leu-O*t*Bu	218
Fmoc-Leu	His	Ser(*t*Bu)-O*t*Bu	219
Fmoc-Leu	His	Thr(*t*Bu)-OtBu	220
Fmoc-Lys(εBoc)	His	Ser(*t*Bu)-OtBu	221
Fmoc-Lys(εBoc)	His	Thr(*t*Bu)-OtBu	222
Fmoc-Lys(εBoc)	His	Leu-*OtBu*	223
Fmoc-Lys(εFmoc)	His	Ser(*t*Bu)-O*t*Bu	224
Fmoc-Lys(εFmoc)	His	Thr(*t*Bu)-OtBu	225
Fmoc-norLeu	His	Ser(*t*Bu)-OtBu	226
Fmoc-Phe	His	Ile-O*t*Bu	227
Fmoc-Phe	His	Leu-O*t*Bu	228
Fmoc-Phe	His	norLeu-OtBu	229
Fmoc-Trp	His	Ser(*t*Bu)-O*t*Bu	230
Fmoc-Trp	His	Ile-O*t*Bu	231
Fmoc-Trp	His	Leu-O*t*Bu	232
Fmoc-Trp	His	Phe-O*t*Bu	233
Fmoc-Trp	His	Tyr-O*t*Bu	234
Fmoc-Trp	His	Thr(*t*Bu)-OtBu	235
Nicotinyl Lys(εBoc)	His	Ser(*t*Bu)-O*t*Bu	236
Nicotinyl Lys(εBoc)	His	Thr(*t*Bu)-O*t*Bu	237

[0157] While the pepides of Table 3 are illustrated with particular protecting groups, it is noted that these groups may be substituted with other protecting groups as described herein and/or one or more of the shown protecting group can be eliminated.

2) Small peptides with central acidic and basic amino acids.

[0158] In certain embodiments, the peptides of this invention range from four amino acids to about ten amino acids. The terminal amino acids are typically hydrophobic either because of a hydrophobic side chain or because the terminal amino acids bear one or more hydrophobic protecting groups end amino acids (X^1 and X^4) are hydrophobic either because of a hydrophobic side chain or because the side chain or the C and/or N terminus is blocked with one or more hydrophobic protecting group(s) (*e.g.*, the N-terminus is blocked with Boc-, Fmoc-, Nicotinyl-, *etc.*, and the C-terminus blocked with (*t*Bu)-O*t*Bu, *etc.*). Typically, the central portion of the peptide comprises a basic amino acid and an acidic amino acid (*e.g.* in a 4 mer) or a basic domain and/or an acidic domain in a longer molecule.

[0159] These four-mers can be represented by Formula I in which X^1 and X^4 are hydrophobic and/or bear hydrophobic protecting group(s) as described herein and X^2 is acidic while X^3 is basic or X^2 is basic while X^3 is acidic. The peptide can be all L- amino acids or include one or more or all D-amino acids.

[0160] Certain preferred of this invention include, but are not limited to the peptides shown in Table 4.

[0161] Table 4. Illustrative examples of small peptides with central acidic and basic amino acids.

X^1	X^2	X^3	X^4	SEQ ID NO
Boc-Lys(εBoc)	Arg	Asp	Ser(*t*Bu)-O*t*Bu	238
Boc-Lys(εBoc)	Arg	Asp	Thr(*t*Bu)-O*t*Bu	239
Boc-Trp	Arg	Asp	Ile-O*t*Bu	240
Boc-Trp	Arg	Asp	Leu-O*t*Bu	241
Boc-Phe	Arg	Asp	Leu-O*t*Bu	242
Boc-Phe	Arg	Asp	Ile-O*t*Bu	243
Boc-Phe	Arg	Asp	norLeu-O*t*Bu	244
Boc-Phe	Arg	Glu	norLeu-O*t*Bu	245
Boc-Phe	Arg	Glu	Ile-*OtBu*	246
Boc-Phe	Asp	Arg	Ile-O*t*Bu	247
Boc-Phe	Glu	Arg	Ile-O*t*Bu	248
Boc-Phe	Asp	Arg	Leu-O*t*Bu	249
Boc-Phe	Arg	Glu	Leu-O*t*Bu	250

Boc-Phe	Glu	Arg	Leu-O*t*Bu	251
Boc-Phe	Asp	Arg	norLeu-O*t*Bu	252
Boc-Phe	Glu	Arg	norLeu-O*t*Bu	253
Boc-Lys(εBoc)	Glu	Arg	Ser(*t*Bu)-O*t*Bu	254
Boc-Lys(εBoc)	Glu	Arg	Thr(*t*Bu)-O*t*Bu	255
Boc-Lys(εBoc)	Asp	Arg	Ser(*t*Bu)-O*t*Bu	256
Boc-Lys(εBoc)	Asp	Arg	Thr(*t*Bu)-O*t*Bu	257
Boc-Lys(εBoc)	Arg	Glu	Ser(*t*Bu)-O*t*Bu	258
Boc-Lys(εBoc)	Arg	Glu	Thr(*t*Bu)-O*t*Bu	259
Boc-Leu	Glu	Arg	Ser(*t*Bu)-O*t*Bu	260
Boc-Leu	Glu	Arg	Thr(*t*Bu)-O*t*Bu	261
Fmoc-Trp	Arg	Asp	Ser(*t*Bu)-O*t*Bu	262
Fmoc-Trp	Asp	Arg	Ser(*t*Bu)-O*t*Bu	263
Fmoc-Trp	Glu	Arg	Ser(*t*Bu)-O*t*Bu	264
Fmoc-Trp	Arg	Glu	Ser(*t*Bu)-O*t*Bu	265
Boc-Lys(εBoc)	Glu	Arg	Leu-*Ot*Bu	266
Fmoc-Leu	Arg	Asp	Ser(*t*Bu)-O*t*Bu	267
Fmoc-Leu	Asp	Arg	Ser(*t*Bu)-O*t*Bu	268
Fmoc-Leu	Glu	Arg	Ser(*t*Bu)-O*t*Bu	269
Fmoc-Leu	Arg	Glu	Ser(*t*Bu)-O*t*Bu	270
Fmoc-Leu	Arg	Asp	Thr(*t*Bu)-O*t*Bu	271
Boc-Glu	Asp	Arg	Tyr(*t*Bu)-O*t*Bu	272
Fmoc-Lys(εFmoc)	Arg	Asp	Ser(*t*Bu)-O*t*Bu	273
Fmoc-Trp	Arg	Asp	Ile-O*t*Bu	274
Fmoc-Trp	Arg	Asp	Leu-O*t*Bu	275
Fmoc-Phe	Arg	Asp	Ile-O*t*Bu	276
Fmoc-Phe	Arg	Asp	Leu-O*t*Bu	277
Boc-Trp	Arg	Asp	Phe-O*t*Bu	278
Boc-Trp	Arg	Asp	Tyr-O*t*Bu	279
Fmoc-Trp	Arg	Asp	Phe-O*t*Bu	280
Fmoc-Trp	Arg	Asp	Tyr-O*t*Bu	281
Boc-Orn(δBoc)	Arg	Glu	Ser(*t*Bu)-O*t*Bu	282
Nicotinyl Lys(εBoc)	Arg	Asp	Ser(*t*Bu)-O*t*Bu	283
Nicotinyl Lys(εBoc)	Arg	Asp	Thr(*t*Bu)-O*t*Bu	284
Fmoc-Leu	Asp	Arg	Thr(*t*Bu)-OtBu	285
Fmoc-Leu	Glu	Arg	Thr(*t*Bu)-OtBu	286
Fmoc-Leu	Arg	Glu	Thr(*t*Bu)-OtBu	287
Fmoc-norLeu	Arg	Asp	Ser(*t*Bu)-OtBu	288
Fmoc-norLeu	Asp	Arg	Ser(*t*Bu)-OtBu	289

Fmoc-norLeu	Glu	Arg	Ser(*t*Bu)-OtBu	290
Fmoc-norLeu	Arg	Glu	Ser(*t*Bu)-OtBu	291
Fmoc-Lys(εBoc)	Arg	Asp	Ser(*t*Bu)-OtBu	292
Fmoc-Lys(εBoc)	Arg	Asp	Thr(*t*Bu)-OtBu	293
Fmoc-Lys(εBoc)	Glu	Arg	Ser(*t*Bu)-OtBu	294
Fmoc-Lys(εBoc)	Glu	Arg	Thr(*t*Bu)-OtBu	295
Fmoc-Lys(εBoc)	Asp	Arg	Ser(*t*Bu)-OtBu	296
Fmoc-Lys(εBoc)	Asp	Arg	Thr(*t*Bu)-OtBu	297
Fmoc-Lys(εBoc)	Arg	Glu	Ser(*t*Bu)-OtBu	298
Fmoc-Lys(εBoc)	Arg	Glu	Thr(*t*Bu)-OtBu	299
Fmoc-Lys(εBoc)	Glu	Arg	Leu-*OtBu*	300
Fmoc-Lys(εBoc)	Arg	Glu	Leu-*OtBu*	301
Fmoc-Lys(εFmoc)	Arg	Asp	Thr(*t*Bu)-OtBu	302
Fmoc- Lys(εFmoc)	Glu	Arg	Ser(*t*Bu)-OtBu	303
Fmoc- Lys(εFmoc)	Glu	Arg	Thr(*t*Bu)-OtBu	304
Fmoc- Lys(εFmoc)	Asp	Arg	Ser(*t*Bu)-OtBu	305
Fmoc- Lys(εFmoc)	Asp	Arg	Thr(*t*Bu)-OtBu	306
Fmoc- Lys(εFmoc)	Arg	Glu	Ser(*t*Bu)-OtBu	307
Fmoc- Lys(εFmoc)	Arg	Glu	Thr(*t*Bu)-OtBu	308
Fmoc- Lys(εFmoc))	Glu	Arg	Leu-*OtBu*	309
Boc-Lys(εFmoc)	Arg	Asp	Ser(*t*Bu)-OtBu	310
Boc-Lys(εFmoc)	Arg	Asp	Thr(*t*Bu)-OtBu	311
Boc-Lys(εFmoc)	Glu	Arg	Ser(*t*Bu)-OtBu	312
Boc-Lys(εFmoc)	Glu	Arg	Thr(*t*Bu)-OtBu	313
Boc-Lys(εFmoc)	Asp	Arg	Ser(*t*Bu)-OtBu	314
Boc-Lys(εFmoc)	Asp	Arg	Thr(*t*Bu)-OtBu	315
Boc-Lys(εFmoc)	Arg	Glu	Ser(*t*Bu)-OtBu	316
Boc-Lys(εFmoc)	Arg	Glu	Thr(*t*Bu)-OtBu	317
Boc-Lys(εFmoc)	Glu	Arg	Leu-*OtBu*	318
Boc-Orn(δFmoc)	Arg	Glu	Ser(*t*Bu)-OtBu	319
Boc-Orn(δFmoc)	Glu	Arg	Ser(*t*Bu)-OtBu	320
Boc-Orn(δFmoc)	Arg	Asp	Ser(*t*Bu)-OtBu	321
Boc-Orn(δFmoc)	Asp	Arg	Ser(*t*Bu)-OtBu	322
Boc-Orn(δFmoc)	Asp	Arg	Thr(*t*Bu)-OtBu	323
Boc-Orn(δFmoc)	Arg	Asp	Thr(*t*Bu)-OtBu	324
Boc-Orn(δFmoc)	Glu	Arg	Thr(*t*Bu)-OtBu	325
Boc-Orn(δFmoc)	Arg	Glu	Thr(*t*Bu)-OtBu	326
Fmoc-Trp	Asp	Arg	Ile-OtBu	327

Fmoc-Trp	Arg	Glu	Ile-OtBu	328
Fmoc-Trp	Glu	Arg	Ile-OtBu	329
Fmoc-Trp	Asp	Arg	Leu-OtBu	330
Fmoc-Trp	Arg	Glu	Leu-OtBu	331
Fmoc-Trp	Glu	Arg	Leu-OtBu	332
Fmoc-Phe	Asp	Arg	Ile-OtBu	333
Fmoc-Phe	Arg	Glu	Ile-OtBu	334
Fmoc-Phe	Glu	Arg	Ile-OtBu	335
Fmoc-Phe	Asp	Arg	Leu-OtBu	336
Fmoc-Phe	Arg	Glu	Leu-OtBu	337
Fmoc-Phe	Glu	Arg	Leu-OtBu	338
Fmoc-Trp	Arg	Asp	Phe-OtBu	339
Fmoc-Trp	Arg	Glu	Phe-OtBu	340
Fmoc-Trp	Glu	Arg	Phe-OtBu	341
Fmoc-Trp	Asp	Arg	Tyr-OtBu	342
Fmoc-Trp	Arg	Glu	Tyr-OtBu	343
Fmoc-Trp	Glu	Arg	Tyr-OtBu	344
Fmoc-Trp	Arg	Asp	Thr(*t*Bu)-OtBu	345
Fmoc-Trp	Asp	Arg	Thr(*t*Bu)-OtBu	346
Fmoc-Trp	Arg	Glu	Thr(*t*Bu)-OtBu	347
Fmoc-Trp	Glu	Arg	Thr(*t*Bu)-OtBu	348
Fmoc-Phe	Arg	Asp	norLeu-OtBu	349
Fmoc-Phe	Arg	Glu	norLeu-OtBu	350
Boc-Phe	Lys	Asp	Leu-OtBu	351
Boc-Phe	Asp	Lys	Leu-OtBu	352
Boc-Phe	Lys	Glu	Leu-OtBu	353
Boc-Phe	Glu	Lys	Leu-OtBu	354
Boc-Phe	Lys	Asp	Ile-OtBu	355
Boc-Phe	Asp	Lys	Ile-OtBu	356
Boc-Phe	Lys	Glu	Ile-OtBu	357
Boc-Phe	Glu	Lys	Ile-OtBu	358
Boc-Phe	Lys	Asp	norLeu-OtBu	359
Boc-Phe	Asp	Lys	norLeu-OtBu	360
Boc-Phe	Lys	Glu	norLeu-OtBu	361
Boc-Phe	Glu	Lys	norLeu-OtBu	362
Boc-Phe	His	Asp	Leu-OtBu	363
Boc-Phe	Asp	His	Leu-OtBu	364
Boc-Phe	His	Glu	Leu-OtBu	365
Boc-Phe	Glu	His	Leu-OtBu	366

Boc-Phe	His	Asp	Ile-OtBu	367
Boc-Phe	Asp	His	Ile-OtBu	368
Boc-Phe	His	Glu	Ile-OtBu	369
Boc-Phe	Glu	His	Ile-OtBu	370
Boc-Phe	His	Asp	norLeu-OtBu	371
Boc-Phe	Asp	His	norLeu-OtBu	372
Boc-Phe	His	Glu	norLeu-OtBu	373
Boc-Phe	Glu	His	norLeu-OtBu	374
Boc-Lys(εBoc)	Lys	Asp	Ser(*t*Bu)-OtBu	375
Boc-Lys(εBoc)	Asp	Lys	Ser(*t*Bu)-OtBu	376
Boc-Lys(εBoc)	Lys	Glu	Ser(*t*Bu)-OtBu	377
Boc-Lys(εBoc)	Glu	Lys	Ser(*t*Bu)-OtBu	378
Boc-Lys(εBoc)	His	Asp	Ser(*t*Bu)-OtBu	379
Boc-Lys(εBoc)	Asp	His	Ser(*t*Bu)-OtBu	380
Boc-Lys(εBoc)	His	Glu	Ser(*t*Bu)-OtBu	381
Boc-Lys(εBoc)	Glu	His	Ser(*t*Bu)-OtBu	382

[0162] While the pepides of Table 4 are illustrated with particular protecting groups, it is noted that these groups may be substituted with other protecting groups as described herein and/or one or more of the shown protecting group can be eliminated.

3) Small peptides having either an acidic or basic amino acid in the center together with a central aliphatic amino acid.

[0163] In certain embodiments, the peptides of this invention range from four amino acids to about ten amino acids. The terminal amino acids are typically hydrophobic either because of a hydrophobic side chain or because the terminal amino acids bear one or more hydrophobic protecting groups. End amino acids (X^1 and X^4) are hydrophobic either because of a hydrophobic side chain or because the side chain or the C and/or N terminus is blocked with one or more hydrophobic protecting group(s) (*e.g.*, the N-terminus is blocked with Boc-, Fmoc-, Nicotinyl-, *etc.*, and the C-terminus blocked with (*t*Bu)-O*t*Bu, *etc.*). Typically, the central portion of the peptide comprises a basic or acidic amino acid and an aliphatic amino acid (*e.g.* in a 4 mer) or a basic domain or an acidic domain and an aliphatic domain in a longer molecule.

[0164] These four-mers can be represented by Formula I in which X^1 and X^4 are hydrophobic and/or bear hydrophobic protecting group(s) as described herein and X^2 is acidic or basic while X^3 is aliphatic or X^2 is aliphatic while X^3 is acidic or basic. The peptide can be all L- amino acids or include one, or more, or all D-amino acids.

[0165] Certain preferred of this invention include, but are not limited to the peptides shown in Table 5.

[0166] Table 5. Examples of certain preferred peptides having either an acidic or basic amino acid in the center together with a central aliphatic amino acid.

X^1	X^2	X^3	X^4	SEQ ID NO
Fmoc-Lys(εBoc)	Leu	Arg	Ser(*t*Bu)-OtBu	383
Fmoc-Lys(εBoc)	Arg	Leu	Ser(*t*Bu)-OtBu	384
Fmoc-Lys(εBoc)	Leu	Arg	Thr(*t*Bu)-OtBu	385
Fmoc-Lys(εBoc)	Arg	Leu	Thr(*t*Bu)-OtBu	386
Fmoc-Lys(εBoc)	Glu	Leu	Ser(*t*Bu)-OtBu	387
Fmoc-Lys(εBoc)	Leu	Glu	Ser(*t*Bu)-OtBu	388
Fmoc-Lys(εBoc)	Glu	Leu	Thr(*t*Bu)-OtBu	389
Fmoc-Lys(εBoc)	Leu	Glu	Thr(*t*Bu)-OtBu	390
Fmoc- Lys(εFmoc)	Leu	Arg	Ser(*t*Bu)-OtBu	391
Fmoc- Lys(εFmoc)	Leu	Arg	Thr(*t*Bu)-OtBu	392
Fmoc- Lys(εFmoc)	Glu	Leu	Ser(*t*Bu)-OtBu	393
Fmoc- Lys(εFmoc)	Glu	Leu	Thr(*t*Bu)-OtBu	394
Boc-Lys(Fmoc)	Glu	Ile	Thr(*t*Bu)-OtBu	395
Boc-Lys(εFmoc)	Leu	Arg	Ser(*t*Bu)-OtBu	396
Boc-Lys(εFmoc)	Leu	Arg	Thr(*t*Bu)-OtBu	397
Boc-Lys(εFmoc)	Glu	Leu	Ser(*t*Bu)-OtBu	398
Boc-Lys(εFmoc)	Glu	Leu	Thr(*t*Bu)-OtBu	399
Boc-Lys(εBoc)	Leu	Arg	Ser(*t*Bu)-OtBu	400
Boc-Lys(εBoc)	Arg	Phe	Thr(*t*Bu)-OtBu	401
Boc-Lys(εBoc)	Leu	Arg	Thr(*t*Bu)-OtBu	402
Boc-Lys(εBoc)	Glu	Ile	Thr(*t*Bu)	403
Boc-Lys(εBoc)	Glu	Val	Thr(*t*Bu)	404
Boc-Lys(εBoc)	Glu	Ala	Thr(*t*Bu)	405
Boc-Lys(εBoc)	Glu	Gly	Thr(*t*Bu)	406
Boc--Lys(εBoc)	Glu	Leu	Ser(*t*Bu)-OtBu	407

Boc-Lys(εBoc)	Glu	Leu	Thr(*t*Bu)-OtBu	408

[0167] While the pepides of Table 5 are illustrated with particular protecting groups, it is noted that these groups may be substituted with other protecting groups as described herein and/or one or more of the shown protecting group can be eliminated.

4) Small peptides having either an acidic or basic amino acid in the center together with a central aromatic amino acid.

[0168] In certain embodiments, the peptides of this invention range from four amino acids to about ten amino acids. The terminal amino acids are typically hydrophobic either because of a hydrophobic side chain or because the terminal amino acids bear one or more hydrophobic protecting groups end amino acids (X^1 and X^4) are hydrophobic either because of a hydrophobic side chain or because the side chain or the C and/or N terminus is blocked with one or more hydrophobic protecting group(s) (*e.g.*, the N-terminus is blocked with Boc-, Fmoc-, Nicotinyl-, *etc.*, and the C-terminus blocked with (*t*Bu)-O*t*Bu, *etc.*). Typically, the central portion of the peptide comprises a basic or acidic amino acid and an aromatic amino acid (*e.g.* in a 4 mer) or a basic domain or an acidic domain and an aromatic domain in a longer molecule.

[0169] These four-mers can be represented by Formula I in which X^1 and X^4 are hydrophobic and/or bear hydrophobic protecting group(s) as described herein and X^2 is acidic or basic while X^3 is aromatic or X^2 is aromatic while X^3 is acidic or basic. The peptide can be all L- amino acids or include one, or more, or all D-amino acids. Five-mers can be represented by a minor modification of Formula I in which X^5 is inserted as shown in Table 6 and in which X^5 is typically an aromatic amino acid.

[0170] Certain preferred of this invention include, but are not limited to the peptides shown in Table 6.

[0171] Table 6. Examples of certain preferred peptides having either an acidic or basic amino acid in the center together with a central aromatic amino acid.

X^1	X^2	X^3	X^5	X^4	SEQ ID NO
Fmoc-Lys(εBoc)	Arg	Trp		Tyr(*t*Bu)-OtBu	409
Fmoc-Lys(εBoc)	Trp	Arg		Tyr(*t*Bu)-OtBu	410
Fmoc-Lys(εBoc)	Arg	Tyr		Trp-OtBu	411
Fmoc-Lys(εBoc)	Tyr	Arg		Trp-OtBu	412
Fmoc-Lys(εBoc)	Arg	Tyr	Trp	Thr(*t*Bu)-OtBu	413
Fmoc-Lys(εBoc)	Arg	Tyr		Thr(*t*Bu)-OtBu	414
Fmoc-Lys(εBoc)	Arg	Trp		Thr(*t*Bu)-OtBu	415
Fmoc- Lys(εFmoc)	Arg	Trp		Tyr(*t*Bu)-OtBu	416
Fmoc- Lys(εFmoc)	Arg	Tyr		Trp-OtBu	417
Fmoc- Lys(εFmoc)	Arg	Tyr	Trp	Thr(*t*Bu)-OtBu	418
Fmoc- Lys(εFmoc)	Arg	Tyr		Thr(*t*Bu)-OtBu	419
Fmoc- Lys(εFmoc)	Arg	Trp		Thr(*t*Bu)-OtBu	420
Boc-Lys(εFmoc)	Arg	Trp		Tyr(*t*Bu)-OtBu	421
Boc-Lys(εFmoc)	Arg	Tyr		Trp-OtBu	422
Boc-Lys(εFmoc)	Arg	Tyr	Trp	Thr(*t*Bu)-OtBu	423
Boc-Lys(εFmoc)	Arg	Tyr		Thr(*t*Bu)-OtBu	424
Boc-Lys(εFmoc)	Arg	Trp		Thr(*t*Bu)-OtBu	425
Boc-Glu	Lys(εFmoc)	Arg		Tyr(*t*Bu)-OtBu	426
Boc-Lys(εBoc)	Arg	Trp		Tyr(*t*Bu)-OtBu	427
Boc-Lys(εBoc)	Arg	Tyr		Trp-OtBu	428
Boc-Lys(εBoc)	Arg	Tyr	Trp	Thr(*t*Bu)-OtBu	429
Boc-Lys(εBoc)	Arg	Tyr		Thr(*t*Bu)-OtBu	430
Boc-Lys(εBoc)	Arg	Phe		Thr(*t*Bu)-OtBu	431
Boc-Lys(εBoc)	Arg	Trp		Thr(*t*Bu)-OtBu	432

[0172] While the pepides of Table 6 are illustrated with particular protecting groups, it is noted that these groups may be substituted with other protecting groups as described herein and/or one or more of the shown protecting group can be eliminated.

<u>5) Small peptides having aromatic amino acids or aromatic amino acids separated by histidine(s) at the center.</u>

[0173] In certain embodiments, the peptides of this invention are characterized by π electrons that are exposed in the center of the molecule which allow hydration of the

particle and that allow the peptide particles to trap pro-inflammatory oxidized lipids such as fatty acid hydroperoxides and phospholipids that contain an oxidation product of arachidonic acid at the sn-2 position.

[0174] In certain embodiments, these peptides consist of a minimum of 4 amino acids and a maximum of about 10 amino acids, preferentially (but not necessarily) with one or more of the amino acids being the D-sterioisomer of the amino acid, with the end amino acids being hydrophobic either because of a hydrophobic side chain or because the terminal amino acid(s) bear one or more hydrophobic blocking group(s), (*e.g.,* an N-terminus blocked with Boc-, Fmoc-, Nicotinyl-, and the like, and a C-terminus blocked with (*t*Bu)-O*t*Bu groups and the like). Instead of having an acidic or basic amino acid in the center, these peptides generally have an aromatic amino acid at the center or have aromatic amino acids separated by histidine in the center of the peptide.

[0175] Certain preferred of this invention include, but are not limited to the peptides shown in Table 7.

[0176] Table 7. Examples of peptides having aromatic amino acids in the center or aromatic amino acids or aromatic domains separated by one or more histidines.

X^1	X^2	X^3	X^4	X^5	SEQ ID NO
Boc-Lys(εBoc)	Phe	Trp	Phe	Ser(*t*Bu)-OtBu	433
Boc-Lys(εBoc)	Phe	Trp	Phe	Thr(*t*Bu)-OtBu	434
Boc-Lys(εBoc)	Phe	Tyr	Phe	Ser(*t*Bu)-OtBu	435
Boc-Lys(εBoc)	Phe	Tyr	Phe	Thr(*t*Bu)-OtBu	436
Boc-Lys(εBoc)	Phe	His	Phe	Ser(*t*Bu)-OtBu	437
Boc-Lys(εBoc)	Phe	His	Phe	Thr(*t*Bu)-OtBu	438
Boc-Lys(εBoc)	Val	Phe	Phe-Tyr	Ser(*t*Bu)-OtBu	439
Nicotinyl-Lys(εBoc)	Phe	Trp	Phe	Ser(*t*Bu)-OtBu	440
Nicotinyl-Lys(εBoc)	Phe	Trp	Phe	Thr(*t*Bu)-OtBu	441
Nicotinyl-Lys(εBoc)	Phe	Tyr	Phe	Ser(*t*Bu)-OtBu	442
Nicotinyl-Lys(εBoc)	Phe	Tyr	Phe	Thr(*t*Bu)-OtBu	443
Nicotinyl-Lys(εBoc)	Phe	His	Phe	Ser(*t*Bu)-OtBu	444
Nicotinyl-Lys(εBoc)	Phe	His	Phe	Thr(*t*Bu)-OtBu	445
Boc-Leu	Phe	Trp	Phe	Thr(*t*Bu)-OtBu	446
Boc-Leu	Phe	Trp	Phe	Ser(*t*Bu)-OtBu	447

[0177] While the pepides of Table 7 are illustrated with particular protecting groups, it is noted that these groups may be substituted with other protecting groups as described herein and/or one or more of the shown protecting group can be eliminated.

6) Summary of tripeptides and tetrapeptides.

[0178] For the sake of clarity, a number of tripeptides and tetrapeptides of this invention are generally summarized below in Table 8.

[0179] Table 8. General structure of certain peptides of this invention.

X^1	X^2	X^3	X^4
hydrophobic side chain or hydrophobic protecting group(s)	Acidic or Basic	----	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Basic	Acidic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Acidic	Basic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Acidic or Basic	Aliphatic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Aliphatic	Acidic or Basic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Acidic or Basic	Aromatic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Aromatic	Acidic or Basic	hydrophobic side chain or hydrophobic protecting group(s)
hydrophobic side chain or hydrophobic protecting group(s)	Aromatic	His Aromatic	hydrophobic side chain or hydrophobic protecting group(s)

[0180] Where longer peptides are desired, X^2 and X^3 can represent domains (*e.g.* regions of two or more amino acids of the specified type) rather than individual amino acids. Table 8 is intended to be illustrative and not limiting. Using the teaching provided herein, other suitable peptides can readily be identified.

D) Other peptide modifications.

[0181] It was a surprising discovery that the peptides described herein, particular when they incorporated one or more D-amino acids, they retained their activity and could also be administered orally. Moreover this oral administration resulted in relatively efficient uptake and significant serum half-life thereby providing an efficacious method of mitigating one or more symptoms of atherosclerosis or other pathologies characterized by an inflammatory process.

[0182] Using the teaching provided herein, one of skill can routinely modify the illustrated peptides to produce other similar peptides of this invention. For example, routine conservative or semi-conservative substitutions (*e.g.* E for D) can be made of the existing amino acids. The effect of various substitutions on lipid affinity of the resulting peptide can be predicted using the computational method described by Palgunachari *et al.* (1996) *Arteriosclerosis, Thrombosis, & Vascular Biology* 16: 328-338. The peptides can be lengthened or shortened as long as the class A α-helix structure is preserved. In addition, substitutions can be made to render the resulting peptide more similar to peptide(s) endogenously produced by the subject species.

[0183] In certain embodiments, the peptides of this invention comprise "D" forms of the peptides described in U.S. Patent 4,643,988, more preferably "D" forms having one or both termini coupled to protecting groups. In certain embodiments, at least 50% of the enantiomeric amino acids are "D" form, more preferably at least 80% of the enantiomeric amino acids are "D" form, and most preferably at least 90% or even all of the enantiomeric amino acids are "D" form amino acids.

[0184] While, in certain embodiments, the peptides of this invention utilize naturally-occurring amino acids or D forms of naturally occurring amino acids, substitutions with non-naturally occurring amino acids (*e.g.*, methionine sulfoxide,

methionine methylsulfonium, norleucine, episilon-aminocaproic acid, 4-aminobutanoic acid, tetrahydroisoquinoline-3-carboxylic acid, 8-aminocaprylic acid, 4-aminobutyric acid, Lys(N(epsilon)-trifluoroacetyl), α-aminoisobutyric acid, and the like) are also contemplated.

[0185] In addition to the peptides described herein, peptidomimetics are also contemplated herein. Peptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template peptide. These types of non-peptide compound are termed "peptide mimetics" or "peptidomimetics" (Fauchere (1986) *Adv. Drug Res.* 15: 29; Veber and Freidinger (1985) *TINS* p.392; and Evans *et al.* (1987) *J. Med. Chem.* 30: 1229) and are usually developed with the aid of computerized molecular modeling. Peptide mimetics that are structurally similar to therapeutically useful peptides may be used to produce an equivalent therapeutic or prophylactic effect.

[0186] Generally, peptidomimetics are structurally similar to a paradigm polypeptide (*e.g,* 4F, SEQ ID NO: 258 described herein), but have one or more peptide linkages optionally replaced by a linkage selected from the group consisting of: $-CH_2NH-$, $-CH_2S-$, $-CH_2-CH_2-$, -CH=CH- (cis and trans), $-COCH_2-$, $-CH(OH)CH_2-$, $-CH_2SO-$, *etc.* by methods known in the art and further described in the following references: Spatola (1983) p. 267 in *Chemistry and Biochemistry of Amino Acids, Peptides, and Proteins*, B. Weinstein, eds., Marcel Dekker, New York,; Spatola (1983) *Vega Data* 1(3) *Peptide Backbone Modifications.* (general review); Morley (1980) *Trends Pharm Sci* pp. 463-468 (general review); Hudson *et al.* (1979) *Int J Pept Prot Res* 14:177-185 ($-CH_2NH-$, CH_2CH_2-); Spatola *et al.* (1986) *Life Sci* 38:1243-1249 ($-CH_2-S$); Hann, (1982) *J Chem Soc Perkin Trans* I 307-314 (-CH-CH-, cis and trans); Almquist *et al.* (1980) *J Med Chem.* 23:1392-1398 ($-COCH_2-$); Jennings-White *et al.*(1982) *Tetrahedron Lett.* 23:2533 ($-COCH_2-$); Szelke, M. *et al.*, European Appln. EP 45665 (1982) CA: 97:39405 (1982) (-CH(OH)CH2-); Holladay *et al.* (1983) *Tetrahedron Lett* 24:4401-4404 ($-C(OH)CH_2-$); and Hruby (1982) *Life Sci.,* 31:189-199 ($-CH_2-S-$)).

[0187] A particularly preferred non-peptide linkage is $-CH_2NH-$. Such peptide mimetics may have significant advantages over polypeptide embodiments, including, for example: more economical production, greater chemical stability, enhanced

pharmacological properties (half-life, absorption, potency, efficacy, *etc.*), reduced antigenicity, and others.

[0188] In addition, circular permutations of the peptides described herein or constrained peptides (including cyclized peptides) comprising a consensus sequence or a substantially identical consensus sequence variation may be generated by methods known in the art (Rizo and Gierasch (1992) *Ann. Rev. Biochem.* 61: 387); for example, by adding internal cysteine residues capable of forming intramolecular disulfide bridges which cyclize the peptide.

IX. Functional assays of peptides.

[0189] Certain peptides of this invention are desctribed herein by various formulas (*e.g.* Formula I, above) and/or by particular sequences. In certain embodiments, however, preferred peptides of this invention are characterized by one or more of the following functional properties:

1 They convert pro-inflammatory HDL to anti-inflammatory HDL or make anti-inflammatory HDL more anti-inflammatory;

2 They decrease LDL-induced monocyte chemotactic activity generated by artery wall cells;

3 They stimulate the formation and cycling of pre-β HDL ;

4 They raise HDL cholesterol; and/or

5 They increase HDL paraoxonase activity.

[0190] The specific peptides disclosed herein, and/or peptides corresponding to the various formulas described herein can readily be tested for one or more of these activities as desired.

[0191] Methods of screening for each of these functional properties are well known to those of skill in the art. In addition, such screens are illustrated herein in the Examples. In particular, it is noted that assays for monocyte chemotactic activity, HDL cholesterol, and HDL HDL paraoxonase activity are illustrated in PCT/US01/26497 (WO 02/15923). Assays for determining HDL inflammatory and/or anti-inflammatory properties were performed as described below.

A) Determination of HDL Inflammatory/Anti-inflammatory Properties-

1) Monocyte Chemotactic Activity (MCA) Assay

[0192] Lipoproteins, human artery wall cocultures, and monocytes were prepared and monocyte chemotactic activity (MCA) was determined as previously described (Van Lenten *et al.* (2002) *Circulation*, 106: 1127-1132). Induction of MCA by a standard control LDL was determined in the absence or presence of the subject's HDL. Values in the absence of HDL were normalized to 1.0. Values greater than 1.0 after the addition of HDL indicated pro-inflammatory HDL; values less than 1.0 indicated anti-inflammatory HDL.

2) Cell-free Assay-

[0193] The cell-free assay was a modification of a previously published method[9] using PEIPC as the fluorescence-inducing agent. Briefly, HDL was isolated by dextran sulfate method. Sigma "HDL cholesterol reagent" (Catalog No. 352-3) containing dextran sulfate and magnesium ions was dissolved in distilled water (10.0 mg/ml). Fifty microliters of dextran sulfate solution was mixed with 500 μl of the test plasma and incubated at room temperature for 5 min and subsequently centrifuged at 8,000 *g* for 10 min. The supernatant containing HDL was used in the experiments after cholesterol determination using a cholesterol assay kit (Cat. No. 2340-200, Thermo DMA Company, Arlington, TX). We have previously reported (Navab *et al.* (2001) *J Lipid Res*, 1308-1317) that HDL isolated by this method inactivates bioactive phospholipids to a similar extent as compared with HDL that has been isolated by conventional ultracentrifuge methods. To determine the inflammatory/anti-inflammatory properties of HDL samples from patients and controls, the change in fluorescence intensity as a result of the oxidation of DCFH by PEIPC in the absence or presence of the test HDL was used. DCFH-DA was dissolved in fresh methanol at 2.0 mg/ml and was incubated at room temperature and protected from light for 30 min. resulting in the release of DCFH. The assay was adapted for analyzing a large number of samples with a plate reader. Flat-bottom, black, polystyrene microtiter plates (Microfluor2,Cat. No. 14-245-176, Fisher) were utilized for this purpose. Ten μl of PEIPC solution (final concentration of 50 μg/ml), and 90 μl of HDL-containing dextran sulfate supernatant (final concentration of 10 μg/ml cholesterol),

were aliquoted into microtiter plates and mixed. The plates were then incubated at 37 °C on a rotator for 1.0 hr. Ten μl of DCFH solution (0.2 mg/ml) was then added to each well, mixed and incubated for an additional 2 hrs at 37 °C with rotation. The fluorescence was subsequently determined with a plate reader (Spectra Max, Gemini XS; Molecular Devices) at an excitation wavelength of 485 nm and emission wavelength of 530 nm and cutoff of 515 nm with the photomultiplier sensitivity set at "medium". Values for intra- and interassay variability were 5.3 ± 1.7% and 7.1 ± 3.2%, respectively. Values in the absence of HDL were normalized to 1.0. Values greater than 1.0 after the addition of the test HDL indicated pro-inflammatory HDL; values less than 1.0 indicated anti-inflammatory HDL.

3) Other Procedures

[0194] Plasma levels of interleukin-6 (IL-6) and tumor necrosis factor-α (TNF- α) were determined by previously published methods (Scheidt-Nave *et al.* (2001) *J Clin Endocrinol Metab.*, 86:2032-2042; Piguet *et al.* (1987) *J Experiment Med.*, 166, 1280-1289). Plasma total cholesterol, triglycerides, LDL-cholesterol, HDL-cholesterol and glucose were determined as previously described (Navab *et al.* (1997) J Clin Invest, 99:2005-2019) using kits (Sigma), and hs-CRP levels (Rifai *et al.* (1999) *Clin Chem.*, 45:2136-2141) were determined using a sandwich enzyme immunoassay from Immunodiagnostik (ALPCO Diagnostics, Windham, NH). Statistical significance was determined with model I ANOVA, and significance was defined as a value of $p < 0.05$.

[0195] It is noted that these methods are merely illustrative and not intended to be limiting. Using the teachings provided herein, other assays for the desired functional proeperties of the peptides can readily be provided.

X. Peptide preparation.

A) General synthesis methods.

[0196] The peptides used in this invention can be chemically synthesized using standard chemical peptide synthesis techniques or, particularly where the peptide does not comprise "D" amino acid residues, the peptide can readily be recombinantly expressed. Where the "D" polypeptides are recombinantly expressed, a host organism (*e.g.* bacteria,

plant, fungal cells, *etc.*) can be cultured in an environment where one or more of the amino acids is provided to the organism exclusively in a D form. Recombinantly expressed peptides in such a system then incorporate those D amino acids.

[0197] In certain embodiments, D amino acids can be incorporated in recombinantly expressed peptides using modified amino acyl-tRNA synthetases that recognize D-amino acids.

[0198] In certain preferred embodiments the peptides are chemically synthesized by any of a number of fluid or solid phase peptide synthesis techniques known to those of skill in the art. Solid phase synthesis in which the C-terminal amino acid of the sequence is attached to an insoluble support followed by sequential addition of the remaining amino acids in the sequence is a preferred method for the chemical synthesis of the polypeptides of this invention. Techniques for solid phase synthesis are well known to those of skill in the art and are described, for example, by Barany and Merrifield (1963) *Solid-Phase Peptide Synthesis;* pp. 3-284 *in The Peptides: Analysis, Synthesis, Biology. Vol. 2: Special Methods in PeptideSynthesis, Part A.*; Merrifield *et al.* (1963) *J. Am. Chem. Soc.*, 85: 2149-2156, and Stewart *et al.* (1984) *Solid Phase Peptide Synthesis,* 2nd ed. Pierce Chem. Co., Rockford, Ill.

[0199] In one embodiment, the peptides are synthesized by the solid phase peptide synthesis procedure using a benzhyderylamine resin (Beckman Bioproducts, 0.59 mmol of NH_2/g of resin) as the solid support. The COOH terminal amino acid (*e.g., t-*butylcarbonyl-Phe) is attached to the solid support through a 4-(oxymethyl)phenacetyl group. This is a more stable linkage than the conventional benzyl ester linkage, yet the finished peptide can still be cleaved by hydrogenation. Transfer hydrogenation using formic acid as the hydrogen donor is used for this purpose. Detailed protocols used for peptide synthesis and analysis of synthesized peptides are describe in a miniprint supplement accompanying Anantharamaiah *et al.* (1985) *J. Biol. Chem.*, 260(16): 10248-10255.

[0200] It is noted that in the chemical synthesis of peptides, particularly peptides comprising D amino acids, the synthesis usually produces a number of truncated peptides in addition to the desired full-length product. The purification process (*e.g.* HPLC) typically results in the loss of a significant amount of the full-length product.

[0201] It was a discovery of this invention that, particularly in the synthesis of a D peptide (*e.g.* D-4), in order to prevent loss in purifying the longest form one can dialyze and use the mixture and thereby eliminate the last HPLC purification. Such a mixture loses about 50% of the potency of the highly purified product (*e.g.* per wt of protein product), but the mixture contains about 6 times more peptide and thus greater total activity.

B) Incorporating D-form amino acids.

[0202] D-amino acids can be incorporated at one or more positions in the peptide simply by using a D-form derivatized amino acid residue in the chemical synthesis. D-form residues for solid phase peptide synthesis are commercially available from a number of suppliers (*see, e.g.,* Advanced Chem Tech, Louisville; Nova Biochem, San Diego; Sigma, St Louis; Bachem California Inc., Torrance, *etc.*). The D-form amino acids can be completely omitted or incorporated at any position in the peptide as desired. Thus, for example, in certain embodiments, the peptide can comprise a single D-amino acid, while in other embodiments, the peptide comprises at least two, generally at least three, more generally at least four, most generally at least five, preferably at least six, more preferably at least seven and most preferably at least eight D amino acids. In particularly preferred embodiments, essentially every other (enantiomeric) amino acid is a D-form amino acid. In certain embodiments at least 90%, preferably at least 90%, more preferably at least 95% of the enantiomeric amino acids are D-form amino acids. In one particularly preferred embodiment, essentially every enantiomeric amino acid is a D-form amino acid.

C) Solution phase synthesis methods.

[0203] In certain embodiments, the peptides of this inventioin can readily be synthesized using solution phase methods. One such synthesis scheme is illustrated in Figures 1 and 2.

[0204] In this scheme, A,B, C and D represent amino acids in the desired peptide. X- represents a permanent α-amino protecting group. Y-represents a permanent α-carboxyl protecting group. Letters *m* and *n* represent side chain protecting groups if the N- and C-terminal amino acids possess side chain functional groups. Side chain protecting groups *o* and *p* are protecting groups that can be removed by a treatment such

as catalytic transfer hydrogenation using ammonium formate as the hydrogen donor (Anantharamaiah and Sivanandaiah (1977) *Chem Soc. Perkin Trans.* 490: 1-5; and Babiker *et al.* (1978) *J. Org. Chem.* 44: 3442-3444) under the (neutral) conditions in which side chain protecting groups *m* and *p* and α-amino and α-carboxyl protecting groups are stable. HOBT-HBTU represents condensing reagents under which minimum reacimization is observed.

[0205] To the activated amino acid X-A(*m*) in presence of 1-hydroxybenzotriazole-2(H-Benzotriazole-1-yl)-1,1,3,3-tetramethylammonium hexafluorophosphate (HOBT-HBTU) and a small amount of tertiary amine such diisopropylethylamine (DIEA) in DMF is added 2 equivalents of DIEA salt of H_2N-B(*n*)-COO^- and stirred overnight at room temperature. The reaction is allowed to go to completion with respect to activated carboxylic acid using excess of amino acid in which α-amino is free and carboxyl is temporarily protected as DIEA salt. The reaction mixture is acidified using aqueous citric acid (10%) and extracted with ethyl acetate. In this process the free amino acid remains in citric acid. After washing ethyl acetate with water, the N-terminal protected dipeptide free acid is extracted with 5% sodium bicarbonate solution and acidified. The dipeptide free acid was extracted with ethyl acetate, the organic layer is dried (Na_2SO_4) and solvent evaporated to obtain the dipeptide free acid. The tripeptide is also obtained in a similar manner by reacting the dipeptide free acid with the suitably protected amino acid in which the α-amino is free and the carboxyl is temporarily protected as a DIEA salt. To obtain the tetrapeptide, the suitably carboxyl protected amino acid was condensed using HOBT-HBTU. Since the final tetrapeptide is a protected peptide, the reaction mixture after the condensation was taken in ethyl acetate and washed extensively with both aqueous bicarbonate (5%) and citric acid(5%) and then with water. These washings will remove excess of free acid and free base and the condensing reagents. The protected peptide is then reprecipitated using ethyl acetate (or ether) and petroleum ether. The protected free peptide is then subjected to catalytic transfer hydrogenation in presence of freshly prepared palladium black (Pd black) using ammonium formate as the hydrogen donor. This reaction can be carried out in almost neutral condition thus not affecting the acid sensitive side chain protecting groups. This process will remove the protecting groups on amino acids B and C. An example of this procedure is given below using the synthesis of SEQ ID NO:256.

[0206] It is noted that this reaction scheme is intended to be illustrative and not limiting. Using the teachings provided herein, other suitable reactions schemes will be known to those of skill in the art.

D) Protecting groups.

[0207] In certain embodiments, the one or more R-groups on the constituent amino acids and/or the terminal amino acids are blocked with a protecting group, most preferably a hydrophobic protecting group. Without being bound by a particular theory, it was a discovery of this invention that blockage, particularly of the amino and/or carboxyl termini of the subject peptides of this invention greatly improves oral delivery and significantly increases serum half-life.

[0208] A wide number of protecting groups are suitable for this purpose. Such groups include, but are not limited to acetyl, amide, and alkyl groups with acetyl and alkyl groups being particularly preferred for N-terminal protection and amide groups being preferred for carboxyl terminal protection. In certain embodiments, the blocking groups can additionally act as a detectable label (*e.g.* N-methyl anthranilyl).

[0209] In certain particularly preferred embodiments, the protecting groups include, but are not limited to alkyl chains as in fatty acids, propionyl, formyl, and others. Particularly preferred carboxyl protecting groups include amides, esters, and ether-forming protecting groups. In one preferred embodiment, an acetyl group is used to protect the amino terminus and an amide group is used to protect the carboxyl terminus. These blocking groups enhance the helix-forming tendencies of the peptides. Certain particularly preferred blocking groups include alkyl groups of various lengths, *e.g.* groups having the formula: CH_3-$(CH_2)_n$-CO- where n ranges from about 3 to about 20, preferably from about 3 to about 16, more preferably from about 3 to about 13, and most preferably from about 3 to about 10.

[0210] Other protecting groups include, but are not limited to N-methyl anthranilyl, Fmoc, t-butoxycarbonyl (t-BOC), 9-fluoreneacetyl group, 1-fluorenecarboxylic group, 9-florenecarboxylic group, 9-fluorenone-1-carboxylic group, benzyloxycarbonyl, Xanthyl (Xan), Trityl (Trt), 4-methyltrityl (Mtt), 4-methoxytrityl (Mmt), 4-methoxy-2,3,6-trimethyl-benzenesulphonyl (Mtr), Mesitylene-2-sulphonyl

(Mts), 4,4-dimethoxybenzhydryl (Mbh),Tosyl (Tos), 2,2,5,7,8-pentamethyl chroman-6-sulphonyl (Pmc), 4-methylbenzyl (MeBzl), 4-methoxybenzyl (MeOBzl), Benzyloxy (BzlO), Benzyl (Bzl), Benzoyl (Bz), 3-nitro-2-pyridinesulphenyl (Npys), 1-(4,4-dimentyl-2,6-diaxocyclohexylidene)ethyl (Dde), 2,6-dichlorobenzyl (2,6-DiCl-Bzl), 2-chlorobenzyloxycarbonyl (2-Cl-Z), 2-bromobenzyloxycarbonyl (2-Br-Z), Benzyloxymethyl (Bom), cyclohexyloxy (cHxO),t-butoxymethyl (Bum), t-butoxy (tBuO), t-Butyl (tBu), Acetyl (Ac), and Trifluoroacetyl (TFA).

[0211] Protecting/blocking groups are well known to those of skill as are methods of coupling such groups to the appropriate residue(s) comprising the peptides of this invention (*see, e.g.,* Greene *et al.,* (1991) *Protective Groups in Organic Synthesis, 2nd ed.,* John Wiley & Sons, Inc. Somerset, N.J.). In one preferred embodiment, for example, acetylation is accomplished during the synthesis when the peptide is on the resin using acetic anhydride. Amide protection can be achieved by the selection of a proper resin for the synthesis. During the synthesis of the peptides described herein in the examples, rink amide resin was used. After the completion of the synthesis, the semipermanent protecting groups on acidic bifunctional amino acids such as Asp and Glu and basic amino acid Lys, hydroxyl of Tyr are all simultaneously removed. The peptides released from such a resin using acidic treatment comes out with the n-terminal protected as acetyl and the carboxyl protected as NH_2 and with the simultaneous removal of all of the other protecting groups.

XI. Enhancing peptide uptake/oral availability.

A) Use of D-amino acids.

[0212] It was also a surprising discovery of this invention that when an all L amino acid peptide (*e.g.* otherwise having the sequence of the peptides of this invention) is administered in conjunction with the D-form (*i.e.* a peptide of this invention) the uptake of the D-form peptide is increased. Thus, in certain embodiments, this invention contemplates the use of combinations of D-form and L-form peptides in the methods of this invention. The D-form peptide and the L-form peptide can have different amino acid sequences, however, in preferred embodiments, they both have amino acid sequences of

peptides described herein, and in still more preferred embodiments, they have the same amino acid sequence.

[0213] It was also a discovery of this invention that concatamers of the class A amphipathic helix peptides of this invention are also effective in mitigating one or more symptoms of atherosclerosis. The monomers comprising the concatamers can be coupled directly together or joined by a linker. In certain embodiments, the linker is an amino acid linker (*e.g.* a proline), or a peptide linker (*e.g.* Gly_4Ser_3) (SEQ ID NO:448). In certain embodiments, the concatamer is a 2 mer, more preferably a 3 mer, still more preferably a 4 mer, and most preferably 5 mer, 8 mer, 10 mer, or 15 mer.

B) Alternating D- and L-amino acids.

[0214] It was discovered that alternating the sterioisoforms of the amino acids at the center of the peptide will allow hydration of the particle and will better allow the peptide particles to trap pro-inflammatory oxidized lipids such as fatty acid hydroperoxides and phospholipids that contain an oxidation product of arachidonic acid at the sn-2 position.

[0215] Thus, in certain embodiments, the peptides described herein can be synthesized to comprise from 4 amino acids to 10-15 amino acids, preferentially (but not necessarily) with the center (non-terminal) amino acids being alternating D and L sterioisomers of the amino acids. The terminal amino acids can be hydrophobic either because of a hydrophobic side chain or because the amino acids bear hydrophobic blocking groups as described herein (*e.g.*, an N-terminus is blocked with Boc-, Fmoc-, Nicotinyl-, and the like and the C-terminus blocked with (*t*Bu)-O*t*Bu and the like.

[0216] Examples of such peptides are illustrated in Table 9.

[0217] Table 9. Certain examples of peptides containign alternating D- and L-residues in the central region.

Sequence	SEQ ID NO
Boc-Lys(εBoc)-D-Arg-L-Asp-Ser(*t*Bu)-O*t*Bu	449
Boc-Lys(εBoc)-L-Arg-D-Asp-Ser(*t*Bu)-O*t*Bu/	450

[0218] It is noted that while specific amino acid sequences are illustrated in Table 9, alternating D- and L-amino acids can be used in any of the peptides described herein.

C) Biotin-derivatized peptides.

[0219] In certain embodiments, any of the peptides described herein can be attached (covalently coupled directly or indirectly through a linker) to one or more biotins. The biotin interacts with the intestinal sodium-dependent multivitamin transporter and thereby facilitates uptake and bioavailability of orally administered peptides.

[0220] The biotin can be directly coupled or coupled through a linker or through a side chain of an amino acid by any of a number of convenient means known to those of skill in the art. In certain embodiments, the biotin is attached to the amino groups of lysine.

[0221] A number of biotin-coupled peptides are illustrated in Table 10.

[0222] Table 10. Examples of certain preferred peptides:

Sequence	SEQ ID NO
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	451
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys-Glu-Ala-Phe-NH_2	452
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	453
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	454
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	455
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	456
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys-Phe-Lys-Glu-Ala-Phe-NH_2	457
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	458
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	459
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys-Glu-Ala-Phe-NH_2	460

Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys-Glu-Ala-Phe-NH_2	461
Ac-Asp-Trp-Phe-Lys(ε-biotin)-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys-Phe-Lys-Glu-Ala-Phe-NH_2	462
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys(ε-biotin)-Val-Ala-Glu-Lys-Phe-Lys-Glu-Ala-Phe-NH_2	463
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys(ε-biotin)-Phe-Lys-Glu-Ala-Phe-NH_2	464
Ac-Asp-Trp-Phe-Lys-Ala-Phe-Tyr-Asp-Lys-Val-Ala-Glu-Lys-Phe-Lys(ε-biotin)-Glu-Ala-Phe-NH_2	465

XII. Pharmaceutical formulations.

[0223] In order to carry out the methods of the invention, one or more peptides or peptide mimetics of this invention are administered, *e.g.* to an individual diagnosed as having one or more symptoms of atherosclerosis, or as being at risk for atherosclerosis. The peptides or peptide mimetics can be administered in the "native" form or, if desired, in the form of salts, esters, amides, prodrugs, derivatives, and the like, provided the salt, ester, amide, prodrug or derivative is suitable pharmacologically, *i.e.,* effective in the present method. Salts, esters, amides, prodrugs and other derivatives of the active agents may be prepared using standard procedures known to those skilled in the art of synthetic organic chemistry and described, for example, by March (1992) *Advanced Organic Chemistry; Reactions, Mechanisms and Structure*, 4th Ed. N.Y. Wiley-Interscience.

[0224] For example, acid addition salts are prepared from the free base using conventional methodology, that typically involves reaction with a suitable acid. Generally, the base form of the drug is dissolved in a polar organic solvent such as methanol or ethanol and the acid is added thereto. The resulting salt either precipitates or may be brought out of solution by addition of a less polar solvent. Suitable acids for preparing acid addition salts include both organic acids, *e.g.,* acetic acid, propionic acid, glycolic acid, pyruvic acid, oxalic acid, malic acid, malonic acid, succinic acid, maleic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid, and the like, as well as inorganic acids, *e.g.,* hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid, and the like. An acid addition salt may be reconverted to the free base by treatment with a suitable base. Particularly preferred acid addition salts of the

active agents herein are halide salts, such as may be prepared using hydrochloric or hydrobromic acids. Conversely, preparation of basic salts of the peptides or mimetics are prepared in a similar manner using a pharmaceutically acceptable base such as sodium hydroxide, potassium hydroxide, ammonium hydroxide, calcium hydroxide, trimethylamine, or the like. Particularly preferred basic salts include alkali metal salts, *e.g.,* the sodium salt, and copper salts.

[0225] Preparation of esters typically involves functionalization of hydroxyl and/or carboxyl groups, that may be present within the molecular structure of the drug. The esters are typically acyl-substituted derivatives of free alcohol groups, *i.e.*, moieties that are derived from carboxylic acids of the formula RCOOH where R is alky, and preferably is lower alkyl. Esters can be reconverted to the free acids, if desired, by using conventional hydrogenolysis or hydrolysis procedures.

[0226] Amides and prodrugs may also be prepared using techniques known to those skilled in the art or described in the pertinent literature. For example, amides may be prepared from esters, using suitable amine reactants, or they may be prepared from an anhydride or an acid chloride by reaction with ammonia or a lower alkyl amine. Prodrugs are typically prepared by covalent attachment of a moiety that results in a compound that is therapeutically inactive until modified by an individual's metabolic system.

[0227] The peptides or mimetics identified herein are useful for parenteral, topical, oral, nasal (or otherwise inhaled), rectal, or local administration, such as by aerosol or transdermally, for prophylactic and/or therapeutic treatment of atherosclerosis and/or symptoms thereof. The pharmaceutical compositions can be administered in a variety of unit dosage forms depending upon the method of administration. Suitable unit dosage forms, include, but are not limited to powders, tablets, pills, capsules, lozenges, suppositories, patches, nasal sprays, injectibles, implantable sustained-release formulations, lipid complexes, *etc.*

[0228] The peptides and/or peptide mimetics of this invention are typically combined with a pharmaceutically acceptable carrier (excipient) to form a pharmacological composition. Pharmaceutically acceptable carriers can contain one or more physiologically acceptable compound(s) that act, for example, to stabilize the composition or to increase or decrease the absorption of the active agent(s).

Physiologically acceptable compounds can include, for example, carbohydrates, such as glucose, sucrose, or dextrans, antioxidants, such as ascorbic acid or glutathione, chelating agents, low molecular weight proteins, protection and uptake enhancers such as lipids, compositions that reduce the clearance or hydrolysis of the active agents, or excipients or other stabilizers and/or buffers.

[0229] Other physiologically acceptable compounds include wetting agents, emulsifying agents, dispersing agents or preservatives that are particularly useful for preventing the growth or action of microorganisms. Various preservatives are well known and include, for example, phenol and ascorbic acid. One skilled in the art would appreciate that the choice of pharmaceutically acceptable carrier(s), including a physiologically acceptable compound depends, for example, on the route of administration of the active agent(s) and on the particular physio-chemical characteristics of the active agent(s).

[0230] The excipients are preferably sterile and generally free of undesirable matter. These compositions may be sterilized by conventional, well-known sterilization techniques.

[0231] In therapeutic applications, the compositions of this invention are administered to a patient suffering from one or more symptoms of atherosclerosis or at risk for atherosclerosis in an amount sufficient to cure or at least partially prevent or arrest the disease and/or its complications. An amount adequate to accomplish this is defined as a "therapeutically effective dose." Amounts effective for this use will depend upon the severity of the disease and the general state of the patient's health. Single or multiple administrations of the compositions may be administered depending on the dosage and frequency as required and tolerated by the patient. In any event, the composition should provide a sufficient quantity of the active agents of the formulations of this invention to effectively treat (ameliorate one or more symptoms) the patient.

[0232] The concentration of peptide or mimetic can vary widely, and will be selected primarily based on fluid volumes, viscosities, body weight and the like in accordance with the particular mode of administration selected and the patient's needs. Concentrations, however, will typically be selected to provide dosages ranging from about 0.1 or 1 mg/kg/day to about 50 mg/kg/day and sometimes higher. Typical dosages range

from about 3 mg/kg/day to about 3.5 mg/kg/day, preferably from about 3.5 mg/kg/day to about 7.2 mg/kg/day, more preferably from about 7.2 mg/kg/day to about 11.0 mg/kg/day, and most preferably from about 11.0 mg/kg/day to about 15.0 mg/kg/day. In certain preferred embodiments, dosages range from about 10 mg/kg/day to about 50 mg/kg/day. It will be appreciated that such dosages may be varied to optimize a therapeutic regimen in a particular subject or group of subjects.

[0233] In certain preferred embodiments, the peptides or peptide mimetics of this invention are administered orally (*e.g.* via a tablet) or as an injectable in accordance with standard methods well known to those of skill in the art. In other preferred embodiments, the peptides, may also be delivered through the skin using conventional transdermal drug delivery systems, *i.e.,* transdermal "patches" wherein the active agent(s) are typically contained within a laminated structure that serves as a drug delivery device to be affixed to the skin. In such a structure, the drug composition is typically contained in a layer, or "reservoir," underlying an upper backing layer. It will be appreciated that the term "reservoir" in this context refers to a quantity of "active ingredient(s)" that is ultimately available for delivery to the surface of the skin. Thus, for example, the "reservoir" may include the active ingredient(s) in an adhesive on a backing layer of the patch, or in any of a variety of different matrix formulations known to those of skill in the art. The patch may contain a single reservoir, or it may contain multiple reservoirs.

[0234] In one embodiment, the reservoir comprises a polymeric matrix of a pharmaceutically acceptable contact adhesive material that serves to affix the system to the skin during drug delivery. Examples of suitable skin contact adhesive materials include, but are not limited to, polyethylenes, polysiloxanes, polyisobutylenes, polyacrylates, polyurethanes, and the like. Alternatively, the drug-containing reservoir and skin contact adhesive are present as separate and distinct layers, with the adhesive underlying the reservoir which, in this case, may be either a polymeric matrix as described above, or it may be a liquid or hydrogel reservoir, or may take some other form. The backing layer in these laminates, which serves as the upper surface of the device, preferably functions as a primary structural element of the "patch" and provides the device with much of its flexibility. The material selected for the backing layer is preferably substantially impermeable to the active agent(s) and any other materials that are present.

[0235] Other preferred formulations for topical drug delivery include, but are not limited to, ointments and creams. Ointments are semisolid preparations, that are typically based on petrolatum or other petroleum derivatives. Creams containing the selected active agent are typically viscous liquid or semisolid emulsions, often either oil-in-water or water-in-oil. Cream bases are typically water-washable, and contain an oil phase, an emulsifier and an aqueous phase. The oil phase, also sometimes called the "internal" phase, is generally comprised of petrolatum and a fatty alcohol such as cetyl or stearyl alcohol; the aqueous phase usually, although not necessarily, exceeds the oil phase in volume, and generally contains a humectant. The emulsifier in a cream formulation is generally a nonionic, anionic, cationic or amphoteric surfactant. The specific ointment or cream base to be used, as will be appreciated by those skilled in the art, is one that will provide for optimum drug delivery. As with other carriers or vehicles, an ointment base should be inert, stable, nonirritating and nonsensitizing.

[0236] Unlike typical peptide formulations, the peptides of this invention comprising D-form amino acids can be administered, even orally, without protection against proteolysis by stomach acid, *etc.* Nevertheless, in certain embodiments, peptide delivery can be enhanced by the use of protective excipients. This is typically accomplished either by complexing the polypeptide with a composition to render it resistant to acidic and enzymatic hydrolysis or by packaging the polypeptide in an appropriately resistant carrier such as a liposome. Means of protecting polypeptides for oral delivery are well known in the art (see, *e.g.*, U.S. Patent 5,391,377 describing lipid compositions for oral delivery of therapeutic agents).

A) Sustained release formulations.

[0237] Elevated serum half-life can be maintained by the use of sustained-release protein "packaging" systems. Such sustained release systems are well known to those of skill in the art. In one preferred embodiment, the ProLease biodegradable microsphere delivery system for proteins and peptides (Tracy (1998) *Biotechnol. Prog.* 14: 108; Johnson *et al.* (1996), *Nature Med.* 2: 795; Herbert *et al.* (1998), *Pharmaceut. Res.* 15, 357) a dry powder composed of biodegradable polymeric microspheres containing the protein in a polymer matrix that can be compounded as a dry formulation with or without other agents.

[0238] The ProLease microsphere fabrication process was specifically designed to achieve a high protein encapsulation efficiency while maintaining protein integrity. The process consists of (i) preparation of freeze-dried protein particles from bulk protein by spray freeze-drying the drug solution with stabilizing excipients, (ii) preparation of a drug-polymer suspension followed by sonication or homogenization to reduce the drug particle size, (iii) production of frozen drug-polymer microspheres by atomization into liquid nitrogen, (iv) extraction of the polymer solvent with ethanol, and (v) filtration and vacuum drying to produce the final dry-powder product. The resulting powder contains the solid form of the protein, which is homogeneously and rigidly dispersed within porous polymer particles. The polymer most commonly used in the process, poly(lactide-co-glycolide) (PLG), is both biocompatible and biodegradable.

[0239] Encapsulation can be achieved at low temperatures (*e.g.*, -40°C). During encapsulation, the protein is maintained in the solid state in the absence of water, thus minimizing water-induced conformational mobility of the protein, preventing protein degradation reactions that include water as a reactant, and avoiding organic-aqueous interfaces where proteins may undergo denaturation. A preferred process uses solvents in which most proteins are insoluble, thus yielding high encapsulation efficiencies (*e.g.*, greater than 95%).

[0240] In another embodiment, one or more components of the solution can be provided as a "concentrate", *e.g.*, in a storage container (*e.g.*, in a premeasured volume) ready for dilution, or in a soluble capsule ready for addition to a volume of water.

B) Combined formulations.

[0241] In certain instances, one or more peptides of this invention are administered in conjunction with one or more active agents (*e.g.* statins, beta blockers, ACE inhibitors, lipids, *etc.*). The two agents (*e.g.* peptide and statin) can be administered simultaneously or sequentially. When administered sequentially the two agents are administered so that both achieve a physiologically relevant concentration over a similar time period (*e.g.* so that both agents are active at some common time).

[0242] In certain embodiments, both agents are administered simultaneously. In such instances it can be convenient to provide both agents in a single combined

formulation. This can be achieved by a variety of methods well known to those of skill in the art. For example, in a tablet formulation the tablet can comprise two layers one layer comprising, *e.g.* the statin(s), and the other layer comprising *e.g.* the peptide(s). In a time release capsule, the capsule can comprise two time release bead sets, one for the peptide(s) and one containing the statin(s).

[0243] The foregoing formulations and administration methods are intended to be illustrative and not limiting. It will be appreciated that, using the teaching provided herein, other suitable formulations and modes of administration can be readily devised.

XIII. Additional pharmacologically active agents.

[0244] Additional pharmacologically active agents may be delivered along with the primary active agents, *e.g.*, the peptides of this invention. In one embodiment, such agents include, but are not limited to agents that reduce the risk of atherosclerotic events and/or complications thereof. Such agents include, but are not limited to beta blockers, beta blockers and thiazide diuretic combinations, statins, aspirin, ace inhibitors, ace receptor inhibitors (ARBs), and the like.

A) Statins.

[0245] It was a surprising discovery that administration of one or more peptides of this invention "concurrently" with one or more statins synergistically enhances the effect of the statin(s). That is, the statins can achieve a similar efficacy at lower dosage thereby obviating potential adverse side effects (*e.g.* muscle wasting) associated with these drugs and/or cause the statins to be significantly more anti-inflammatory at any given dose.

[0246] The major effect of the statins is to lower LDL-cholesterol levels, and they lower LDL-cholesterol more than many other types of drugs. Statins generally inhibit an enzyme, HMG-CoA reductase, which controls the rate of cholesterol production in the body. These drugs typically lower cholesterol by slowing down the production of cholesterol and by increasing the liver's ability to remove the LDL-cholesterol already in the blood.

[0247] The large reductions in total and LDL-cholesterol produced by these drugs appears to result in large reductions in heart attacks and heart disease deaths. Thanks to

their track record in these studies and their ability to lower LDL-cholesterol, statins have become the drugs most often prescribed when a person needs a cholesterol-lowering medicine. Studies using statins have reported 20 to 60 percent lower LDL-cholesterol levels in patients on these drugs. Statins also reduce elevated triglyceride levels and produce a modest increase in HDL-cholesterol. Recently it has been appreciated that statins have anti-inflammatory properties that may not be directly related to the degree of lipid lowering achieved. For example it has been found that statins decrease the plasma levels of the inflammatory marker CRP relatively independent of changes in plasma lipid levels. This anti-inflammatory activity of statins has been found to be as or more important in predicting the reduction in clinical events induced by statins than is the degree of LDL lowering.

[0248] The statins are usually given in a single dose at the evening meal or at bedtime. These medications are often given in the evening to take advantage of the fact that the body makes more cholesterol at night than during the day. When combined with the peptides described herein, the combined peptide/statin treatment regimen will also typically be given in the evening.

[0249] Suitable statins are well known to those of skill in the art. Such statins include, but are not limited to atorvastatin (Lipitor®, Pfizer), simvastatin (Zocor®, Merck0, pravastatin (Pravachol®, Bristol-Myers Squibb®, fluvastatin (Lescol®, Novartis), lovastatin (Mevacor®, Merck), rosuvastatin (Crestor®, Astra Zeneca), and Pitavastatin (Sankyo), and the like.

[0250] The combined statin/peptide dosage can be routinely optimized for each patient. Typically statins show results after several weeks, with a maximum effect in 4 to 6 weeks. Prior to combined treatment with a statin and one of the peptides described herein, the physician would obtain routine tests for starting a statin including LDL-cholesterol and HDL-cholesterol levels. Additionally, the physician would also measure the anti-inflammatory properties of the patient's HDL and determine CRP levels with a high sensitivity assay. After about 4 to 6 weeks of combined treatment, the physician would typically repeat these tests and adjust the dosage of the medications to achieve maximum lipid lowering and maximum anti-inflammatory activity.

B) Cholesterol absorption inhibitors.

[0251] In certain embodiments, one or more peptides of this invention are administered to a subject in conjunction with one or more cholesterol absorption inhibitors. The peptide(s) can be administered before, after, or simultaneously with the cholesterol absorption inhibitor. In the latter case, the cholesterol absorption inhibitor can be provided as a separate formulation or as a combined formulation with one or more of the peptide(s).

[0252] Cholesterol absorption inhibitors are well known to those of skill in the art. One important cholesterol absorption inhibitor is Ezetimibe, also known as 1-(4-fluorophenyl)-3(R)-[3-(4-fluorophenyl)-3(S)-hydroxypropyl]-4(S)-(4-hydroxyphenyl)-2-azetidinone (available from Merck). Ezetimibe reduces blood cholesterol by inhibiting the absorption of cholesterol by the small intestine.

C) Beta blocers.

[0253] Suitable beta blockers include, but are not limited to cardioselective (selective beta 1 blockers), *e.g.*, acebutolol (Sectral™), atenolol (Tenormin™), betaxolol (Kerlone™), bisoprolol (Zebeta™), metoprolol (Lopressor™), and the like. Suitable non-selective blockers (block beta 1 and beta 2 equally) include, but are not limited to carteolol (Cartrol™), nadolol (Corgard™), penbutolol (Levatol™), pindolol (Visken™), carvedilol, (Coreg™), propranolol (Inderal™), timolol (Blockadren™), labetalol (Normodyne™, Trandate™), and the like.

[0254] Suitable beta blocker thiazide diuretic combinations include, but are not limited to Lopressor HCT, ZIAC, Tenoretic, Corzide, Timolide, Inderal LA 40/25, Inderide, Normozide, and the like.

D) ACE inhibitors.

[0255] Suitable ace inhibitors include, but are not limited to captopril (*e.g.* Capoten™ by Squibb), benazepril (*e.g.*, Lotensin™ by Novartis), enalapril (*e.g.*, Vasotec™ by Merck), fosinopril (*e.g.*, Monopril™ by Bristol-Myers), lisinopril (*e.g.* Prinivil™ by Merck or Zestril™ by Astra-Zeneca), quinapril (*e.g.* Accupril™ by Parke-Davis), ramipril (*e.g.*, Altace™ by Hoechst Marion Roussel, King Pharmaceuticals),

imidapril, perindopril erbumine (*e.g.*, Aceon™ by Rhone-Polenc Rorer), trandolapril (*e.g.*, Mavik™ by Knoll Pharmaceutical), and the like. Suitable ARBS (Ace Receptor Blockers) include but are not limited to losartan (*e.g.* Cozaar™ by Merck), irbesartan (*e.g.*, Avapro™ by Sanofi), candesartan (*e.g.*, Atacand™ by Astra Merck), valsartan (*e.g.*, Diovan™ by Novartis), and the like.

E) Lipid-based formulations.

[0256] In certain embodiments, the peptides of this invention are administered in conjunction with one or more lipids. The lipids can be formulated as an active agent, and/or as an excipient to protect and/or enhance transport/uptake of the peptides or they can be administered separately.

[0257] Without being bound by a particular theory, it was discovered of this invention that administration (*e.g.* oral administration) of certain phospholipids can significantly increase HDL/LDL ratios. In addition, it is believed that certain medium-length phospholipids are transported by a process different than that involved in general lipid transport. Thus, co-administration of certain medium-length phospholipids with the peptides of this invention confer a number of advantages: They protect the phospholipids from digestion or hydrolysis, they improve peptide uptake, and they improve HDL/LDL ratios.

[0258] The lipids can be formed into liposomes that encapsulate the polypeptides of this invention and/or they can be simply complexed/admixed with the polypeptides. Methods of making liposomes and encapsulating reagents are well known to those of skill in the art (*see, e.g.*, Martin and Papahadjopoulos (1982) *J. Biol. Chem.*, 257: 286-288; Papahadjopoulos *et al.* (1991) *Proc. Natl. Acad. Sci. USA*, 88: 11460-11464; Huang *et al.* (1992) *Cancer Res.*, 52:6774-6781; Lasic *et al.* (1992) *FEBS Lett.*, 312: 255-258., and the like).

[0259] Preferred phospholipids for use in these methods have fatty acids ranging from about 4 carbons to about 24 carbons in the sn-1 and sn-2 positions. In certain preferred embodiments, the fatty acids are saturated. In other preferred embodiments, the fatty acids can be unsaturated. Various preferred fatty acids are illustrated in Table 11.

[0260] Table 11. Preferred fatty acids in the sn-1 and/or sn-2 position of the preferred phospholipids for administration of D polypeptides.

Carbon No.	Common Name	IUPAC Name
3:0	Propionoyl	Trianoic
4:0	Butanoyl	Tetranoic
5:0	Pentanoyl	Pentanoic
6:0	Caproyl	Hexanoic
7:0	Heptanoyl	Heptanoic
8:0	Capryloyl	Octanoic
9:0	Nonanoyl	Nonanoic
10:0	Capryl	Decanoic
11:0	Undcanoyl	Undecanoic
12:0	Lauroyl	Dodecanoic
13:0	Tridecanoyl	Tridecanoic
14:0	Myristoyl	Tetradecanoic
15:0	Pentadecanoyl	Pentadecanoic
16:0	Palmitoyl	Hexadecanoic
17:0	Heptadecanoyl	Heptadecanoic
18:0	Stearoyl	Octadecanoic
19:0	Nonadecanoyl	Nonadecanoic
20:0	Arachidoyl	Eicosanoic
21:0	Heniecosanoyl	Heniecosanoic
22:0	Behenoyl	Docosanoic
23:0	Trucisanoyl	Trocosanoic
24:0	Lignoceroyl	Tetracosanoic
14:1	Myristoleoyl (9-cis)	
14:1	Myristelaidoyl (9-trans)	
16:1	Palmitoleoyl (9-cis)	
16:1	Palmitelaidoyl (9-trans)	

The fatty acids in these positions can be the same or different. Particularly preferred phospholipids have phosphorylcholine at the sn-3 position.

XIV. Kits.

[0261] In another embodiment this invention provides kits for amelioration of one or more symptoms of atherosclerosis and/or for the prophylactic treatment of a subject

(human or animal) at risk for atherosclerosis and/or for stimulating the formation and cycling of pre-beta high density lipoprotein-like particles and/or for inhibiting one or more symptoms of osteoporosis. The kits preferably comprise a container containing one or more of the peptides or peptide mimetics of this invention. The peptide or peptide mimetic can be provided in a unit dosage formulation (*e.g.* suppository, tablet, caplet, patch, *etc.*) and/or may be optionally combined with one or more pharmaceutically acceptable excipients.

[0262] The kit can, optionally, further comprise one or more other agents used in the treatment of heart disease and/or atherosclerosis. Such agents include, but are not limited to, beta blockers, vasodilators, aspirin, statins, ace inhibitors or ace receptor inhibitors (ARBs) and the like, *e.g.* as described above.

[0263] In certain preferred embodiments, the kits additionally include a statin (*e.g.* cerivastatin, atorvastatin, simvastatin, pravastatin, fluvastatin, lovastatin. rosuvastatin, pitavastatin, *etc.*) either formulated separately or in a combined formulation with the peptide(s). Typically the dosage of a statin in such a formulation can be lower than the dosage of a statin typically presecribed without the synergistic peptide.

[0264] In addition, the kits optionally include labeling and/or instructional materials providing directions (*i.e.*, protocols) for the practice of the methods or use of the "therapeutics" or "prophylactics" of this invention. Preferred instructional materials describe the use of one or more polypeptides of this invention to mitigate one or more symptoms of atherosclerosis and/or to prevent the onset or increase of one or more of such symptoms in an individual at risk for atherosclerosis and/or to stimulate the formation and cycling of pre-beta high density lipoprotein-like particles and/or to inhibit one or more symptoms of osteoporosis. The instructional materials may also, optionally, teach preferred dosages/therapeutic regiment, counter indications and the like.

[0265] While the instructional materials typically comprise written or printed materials they are not limited to such. Any medium capable of storing such instructions and communicating them to an end user is contemplated by this invention. Such media include, but are not limited to electronic storage media (*e.g.*, magnetic discs, tapes, cartridges, chips), optical media (*e.g.*, CD ROM), and the like. Such media may include addresses to internet sites that provide such instructional materials.

EXAMPLES

[0266] The following examples are offered to illustrate, but not to limit the claimed invention.

Example 1

Evaluation of Small Peptides to Mediate Symptoms of Atherosclerosis and other Inflammatory Pathologies.

[0267] The apo A-I mimetic peptides described herein (*see, e.g.*, Table 1) exhibit antiatherogenic properties similar to apo A-I in that they remove the "seeding molecules" (*e.g.*, oxidized phospholipids such as Ox-PAPC, POVPC, PGPC, and PEIPC, *etc.*) necessary for artery wall cells to oxidized LDL and are similar to apo A-I in that they ameliorated atherosclerosis in mouse models.

[0268] The apo A-I mimetic peptides (*e.g.* D-4F, SEQ ID NO:8), differ from apo A-I in that they are also active in a co-incubation similar to apo J (*see, e.g.*, USSN 10/120,508 and PCT/US03/09988). These peptides generally do not have substantial sequence homology to apo A-I, but have homology in their helical structure and in their ability to bind lipids.

[0269] The smaller peptides described herein (*see, e.g.*, Tables 4-7 herein) are similar to native apoA-I in that they prevent LDL oxidation and LDL-induced monocyte chemotactic activity in a pre-incubation with artery wall cells but not in a co-incubation (*see, e.g.*, Figure 3).

[0270] The peptide described in Figure 3 was also active *in vivo* (Figure 4). The tetrapeptide or D-4F (SEQ ID NO:8) were added at 5 μg/ml to the drinking water or not added to the drinking water of apoE null mice (a mouse model of human atherosclerosis). After 18 hours the mice were bled and their lipoproteins isolated by FPLC. Adding the fractions containing mature HDL or the FPLC fractions after these fractions where pre-beta HDL would be expected (particles that come off the FPLC column just after the main HDL peak; post HDL) from mice that received drinking water without peptide increased the monocyte chemotactic activity induced by a control LDL added to a human artery wall cell coculture (Figure 4). In contrast, adding HDL or the post HDL FPLC fractions from the mice that received the tetrapeptide or D-4F in their drinking water significantly

decreased the LDL-induced monocyte chemotactic activity indicating that the tetrapeptide and D-4F converted these lipoproteins from a pro-inflammatory to an anti-inflammatory state (Figure 4).

[0271] As shown in Figure 5, LDL taken from the mice that received the tetrapeptide or D-4F induced significantly less monocyte chemotactic activity than did LDL from mice that did not receive the peptides confirming the biologic activity of the orally administered D-tetrapeptide.

[0272] Figure 6 demonstrates that HDL taken 20 min or 6 hours after SEQ ID NO:258 from Table 4 synthesized from D-amino acids was instilled into the stomachs of apoE null mice by stomach tube, was converted from pro-inflammatory to anti-inflammatory and was similar to that from mice that received D-4F and quite different from mice that received a peptide with the same D-amino acids as in D-4F but arranged in such a way as to prevent the formation of a class A amphipathic helix and hence rendering the peptide unable to bind lipids (scrambled D-4F).

[0273] Figure 7 demonstrates that at both 20 min and 6 hours after oral administration of D-4F or SEQ ID NO:258 synthesized from D-amino acids the mouse LDL was significantly less able to induce monocyte chemotactic activity compared to LDL taken from mice that received the scrambled D-4F peptide.

[0274] Figure 8 demonstrates that adding SEQ ID NO:238 in Table 4 (synthesized from all D-amino acids) to the food of apoE null mice for 18 hours converted the pro-inflammatory HDL of apoE null mice to anti-inflammatory HDL.

[0275] Figure 9 demonstrates that *in vitro* SEQ ID NO:258 in Table 4 was ten times more potent than SEQ ID NO:238.

[0276] As shown in Figure 3 SEQ ID NO:238 at 125 μg/ml was only mildly effective while as shown in Figure 9, SEQ ID NO:258 was highly active at 12.5 μg/ml in a pre-incubation *in vitro*.

[0277] The experiments shown in Figure 10 demonstrate that SEQ ID NO:243, SEQ ID NO: 242, and SEQ ID NO:256 from Table 4 were also able to convert the pro-inflammatory HDL of apoE null mice to anti-inflammatory HDL.

[0278] The activity of particular peptides of this invention is dependent on particular amino acid substitutions as shown in Figures 11, 12, and 13. SEQ ID NO:254 is identical with SEQ ID NO:258 except that the positions of the arginine and glutamic acid amino acids are reversed in the sequence (*i.e.* SEQ ID NO:254 is Boc-Lys(εBoc)-Glu-Arg-Ser(*t*Bu)-O*t*Bu, while SEQ ID NO:258 is Boc-Lys(εBoc)-Arg-Glu-Ser(*t*Bu)-O*t*Bu). As a result of this seemingly minor change, SEQ ID NO: 254 is substantially less effective in these assays than SEQ ID NO:258.

[0279] The experiments described in Figures 11 and 12 demonstrate that SEQ ID NO:258 from Table 4 was more effective in converting pro-inflammatory HDL to anti-inflammatory HDL and rendering LDL less able to induce monocyte chemotactic activity than was either SEQ ID NO:254 or SEQ ID NO:282.

[0280] Serum Amyloid A (SAA) is a positive acute phase reactant in mice that is similar to C-Reactive Protein (CRP) in humans. The data in Figure 13 indicate that this acute phase reactant was significantly reduced in plasma after injection of SEQ ID NO:258 and to a lesser, non-significant degree after injection of SEQ ID NO:254 and 282.

[0281] Figure 14 demonstrates that the peptide described in Table 4 as SEQ ID NO:258, when synthesized from all L-amino acids and given to apoE null mice orally converted pro-inflammatory HDL to anti-inflammatory and increased plasma paraoxonase activity (Figure 15).

[0282] Figures 16, 17, 18, and 19 demonstrate that the peptide described in Table 4 as SEQ ID NO:258 when synthesized from all D-amino acids and given orally to apoE null mice rendered HDL anti-inflammatory (Figures 16 and 17), reducing LDL-induced monocyte chemotactic activity (Figure 17) and increasing plasma HDL-cholesterol (Figure 18) and increasing HDL paraoxonase activity (Figure 19). These data also show that SEQ ID NO:238, when synthesized from all L-amino acids and given orally to apoE null mice, did not significantly alter HDL inflammatory properties (Figures 16 and 17) nor did it significantly alter LDL-induced monocyte chemotactic activity (Figure 17) nor did it significantly alter plasma HDL-cholesterol concentrations (Figure 18), nor did it significantly alter HDL paraoxonase activity (Figure 19). Additionally these data show that when SEQ ID NO:238 from Table 4 was synthesized from all D-amino acids and was given orally to apoE null mice, HDL was rendered anti-inflammatory (Figures 16 and 17),

and reduced LDL-induced monocyte chemotactic activity (Figure 17), but neither change was as dramatic as with SEQ ID NO:258. Moreover, unlike SEQ ID NO:258, SEQ ID NO:238 from Table 4 when synthesized from all D-amino acids did not raise plasma HDL-cholesterol concentrations (Figure 18) and did not increase HDL paraoxonase activity (Figure 19). We conclude that SEQ ID NO:238 from Table 4 when synthesized from L-amino acids is not effective when given orally but is effective when synthesized from D-amino acids, but is substantially less effective than SEQ ID NO:258.

[0283] The data presented herein demonstrate that SEQ ID NO:238 when synthesized from all L-amino acids and given orally is generally ineffective, and when synthesized from all D-amino acids, while effective, is substantially less effective than the same dose of SEQ ID NO:258 synthesized from all D-amino acids when administered orally.

Example 2
Peptides Synergize Statin Activity

[0284] Figures 20 and 21 show the very dramatic synergy between a statin (pravastatin) and D-4F in ameliorating atherosclerosis in apoE null mice. Mice are known to be resistant to statins. The mice that received pravastatin in their drinking water at 20 μg/ml consumed a dose of pravastatin equal to 175 mg per day for a 70Kg human and the mice that received pravastatin in their drinking water at 50 μg/ml consumed a dose of pravastatin equal to 437.5 mg per day for a 70Kg human. As shown in Figures 20 and 21, these very high doses of pravastatin were not effective in ameliorating atherosclerotic lesions in apoE null mice. As shown in Figures 20 and 21, adding D-4F alone to the drinking water of the apoE null mice at concentrations of 2 μg/ml or 5 μg/ml did not reduce atherosclerotic lesions. These doses of D-4F would be equivalent to doses of 17.5 mg per day, and 43.75 mg per day, respectively, for a 70Kg human. Remarkably, as shown in Figures 20 and 21, adding the same concentrations of pravastatin and D-4F together to the drinking water of the apoE null mice essentially abolished atherosclerosis in these mice. This indicates a very high degree of synergy between a statin (pravastatin) and D-4F.

[0285] Figure 22 shows that SEQ ID NO.45232425414223825828222438 and SEQ ID NO. 203 from Table 4 were equally effective or even more effective than D-4F in reducing the lipid hydroperoxide content of both LDL and HDL in apoE null mice. These data are consistent with D-4F and the peptides described in this application acting in part by sequestering the "seeding molecules" necessary for LDL to induce the inflammatory atherosclerotic reaction. Taken together with the data shown in Figures 3 to 19 it is very likely that the peptides described in this application (*e.g.* SEQ ID NO. 198 and SEQ ID NO. 203 from Table 4) will be as or more effective than D-4F in ameliorating atherosclerosis.

[0286] It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims. All publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.